REVISIONS AND CORRECTIONS

AREA Proceedings, Volume 43 (1942)

Changes in the text for correction of typographical errors, and to take account of revisions, deletions and additions requested by committees in presenting their reports.

Page 74, last line of paragraph 4, change figure "40" to "20."

Page 77, in second formula, replace exponent "2" by a coefficient "2".

Page 188, third line of definition of "Push", change "level" to "lever".

Page 189, first sentence, change "final report" to "progress report".

Page 207, second paragraph, change first word from "An" to "As".

Page 392, the statement beginning with final paragraph on this page and continuing on page 393 should follow the text on page 391.

Page 410, between paragraphs 209 and 210, insert paragraph with same wording as appears in paragraph 212.

Page 411, tenth line, delete word "or" following words "To be filled out further".

Page 481, delete words "under Pressure" in title of Assignment 3, and in second line of Assignment 3 (a).

Page 491, in Table 1, eighth column, change sixth figure to $23\frac{3}{16}$; in Table 1—Continued, third column, change fourth figure to $\frac{11}{16}$; in fifth column, change seventh figure to $2\frac{1}{16}$.

Page 508, third line, delete final sentence "Rails clipped, etc." Same applies to seventh line.

Page 509, fourth paragraph, change to read: "*Watchmen.*—Watchmen are employed in tunnels when conditions justify it".

Page 528, paragraph 103, change last sentence to read: "All 'A' rails and 'X-Rayls' are excluded".

Page 571, paragraph 401, last sentence, change "OU" to "CU".

Page 583, under Detected Failures for year 1933, change sixth figure from 372 to 472.

PROCEEDINGS

OF THE

FORTY-THIRD ANNUAL CONVENTION

OF THE

American Railway Engineering Association

HELD AT THE

PALMER HOUSE, CHICAGO, ILLINOIS
March 17, 18 and 19, 1942

VOLUME 43

Copyright, 1942, by
AMERICAN RAILWAY ENGINEERING ASSOCIATION
CHICAGO

A

BOARD OF DIRECTION

President

F. L. C. Bond, Vice-President and General Manager, Canadian National Railways, Toronto, Ont.

Vice-Presidents

H. R. Clarke, Chief Engineer Maintenance of Way, Burlington Lines, Chicago

*W. F. Cummings, Chief Engineer, Boston & Maine Railroad; Maine Central Railroad, Boston, Mass.

Past-Presidents

W. P. Wiltsee, Chief Engineer, Norfolk & Western Railway, Roanoke, Va.

J. E. Armstrong, Chief Engineer, Canadian Pacific Railway, Montreal, Que.

A. R. Wilson, Engineer Bridges and Buildings, Pennsylvania Railroad, Philadelphia, Pa.

F. E. Morrow, Chief Engineer, Chicago & Western Indiana Railroad and Belt Railway of Chicago, Chicago

E. M. Hastings, Chief Engineer, Richmond, Fredericksburg & Potomac Railway, Richmond, Va.

Directors

C. E. Smith, Vice-President, New York, New Haven & Hartford Railroad, New Haven, Conn.

J. B. Akers, Assistant Chief Engineer, Southern Railway System, Washington, D. C.

A. A. Miller, Chief Engineer Maintenance of Way, Missouri Pacific Railroad, St. Louis, Mo.

G. P. Palmer, Engineer Maintenance and Construction, Baltimore & Ohio Chicago Terminal Railroad, Chicago

Armstrong Chinn, Chief Engineer, Alton Railroad, Chicago

F. S. Schwinn, Assistant Chief Engineer, Missouri Pacific Lines, Houston, Tex.

E. T. Howson, Vice-President and Western Editor, Railway Age, Chicago

B. R. Kulp, Chief Engineer, Chicago & North Western Railway, Chicago

---

Treasurer

W. H. Penfield, Chief Engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad, Chicago

Secretary

W. S. Lacher, 59 East Van Buren Street, Chicago

Assistant Secretary

Frank McNellis, 59 East Van Buren Street, Chicago

* Deceased, April 9, 1942.

NUMERICAL INDEX TO COMMITTEE REPORTS

	Report	Discussion
1—Roadway and Ballast	469	731
3—Ties	399	696
4—Rail	573	704
Investigation of Fissures in Railroad Rails	607	
5—Track	515	767
6—Buildings	123	694
7—Wood Bridges and Trestles	243	751
8—Masonry	257	716
9—Highways	167	745
10—Signals and Interlocking	41	682
11—Records and Accounts	379	700
13—Water Service, Fire Protection and Sanitation	73	760
14—Yards and Terminals	141	712
15—Iron and Steel Structures	363	737
16—Economics of Railway Location and Operation	49	684
17—Wood Preservation	405	698
18—Electricity	37	681
20—Uniform General Contract Forms	107	708
22—Economics of Railway Labor	229	691
24—Cooperative Relations With Universities	175	719
25—Waterways and Harbors	47	691
26—Standardization	25	681
27—Maintenance of Way Work Equipment	187	727
28—Clearances		711
Special—Waterproofing of Railway Structures	357	710
Special—Impact	360	759

TABLE OF CONTENTS

GENERAL

PAGE

Constitution 10
General Information 20

COMMITTEE REPORTS

Standardization 25
- Tabulation of Specifications and Recommended Practices Contained in the Manual That Are Presented for Uniform Practice on All Railroads 26
- Representation of Association of American Railroads on Standards Council of American Standards Association 30
- American Standards Association Projects and Representatives Thereon 31
- Collaborating AREA Representatives on ASTM Committees 32
- National Defense Work of ASTM 33
- Canadian Engineering Standards Association (CESA) 35
- Discussion 681

Electricity 37
- Developments in Application of Electricity 37
- Abstract of Reports of Electrical Section 38
- Discussion 681

Signals and Interlocking 41
- Developments in Railway Signaling 41
- Principal Current Activities of the Signal Section 43
- Discussion 682

Waterways and Harbors 47
- Lands Subject to Servitude of Navigation as Affecting Protection of Roadbeds Built or to be Built on Proposed Dam Pool Areas 47
- Discussion 691

Economics of Railway Location and Operation 49
- Train Resistance of Freight Trains under Various Conditions of Loading and Speed 51
- Development of Modern Power Units and the Effects on the Economics of Railway Location and Operation 71
- Discussion 684

Water Service, Fire Protection and Sanitation 73
- Revision of Manual 74
  - Revised Specifications for Cast Iron Pipe 81
- Cause of and Remedy for Pitting and Corrosion of Locomotive Boiler Tubes and Sheets with Special Reference to Status of Embrittlement Investigations 82
- Progress Being Made by Federal or State Authorities on Regulations Pertaining to Railway Sanitation 83

Water Service, Fire Protection and Sanitation—Continued PAGE
Principal Activities of the Fire Protection and Insurance Section of the Association of American Railroads 84
Use of Anti-Foam Compounds to Reduce Road Blowing 85
Specifications for Welded Steel Tanks for Water Service 88
Methods for Cleaning Sewers and Underground Pipe Lines 93
Practicable Size of Water Columns and Supply Lines for Maximum Delivery of Water to Locomotive Tenders 99
Discussion 760

Uniform General Contract Forms 107
Revision of Manual 107
Form of Agreement for Purchase of Electrical Energy for Other Than Traction Purposes 108
Suggestions for Use in Preparing a Lease for Air Right Development 113
Form of Agreement for Wire or Cable Line Crossings 115
Discussion 708

Buildings 123
Revision of Manual 123
Preparation of Specifications for Railway Buildings 127
Railroad Warehouse Requirements for Handling Quick Frozen Products 136
Discussion 694

Yards and Terminals 141
Terminal Facilities Required for Servicing Electrical and Air Conditioning Equipment in Passenger Cars 142
Scales Used in Railway Service 143
Classification Yards 143
Modernization of Passenger Terminals 149
Bibliography on Subjects Pertaining to Yards and Terminals 158
Discussion 712

Highways 167
Revision of Manual 168
Comparative Merits of Various Types of Grade Crossing Protection 169
Requisites for Location, Number and Arrangement of Automatic Signals, Automatic Gates and Auxiliary Signs for Rail-Highway Grade Crossing Protection 172
Discussion 745

Cooperative Relations with Universities 175
Develop Means of Bringing to the Attention of Railway Managements the Value of a Technical Education 177
Stimulate a Greater Interest in the Science of Transportation Among University and College Students 185
Discussion 719

Maintenance of Way Work Equipment 187
Revision of Manual 188
Standardization of Parts and Accessories for Railway Maintenance Motor Cars . 189

Maintenance of Way Work Equipment—Continued PAGE
Lubrication of Roadway Machines 193
Glossary of Lubricating Terms, Oil and Grease, Their Properties and Tests .. 202
Explanation of Common Questions Concerning Lubrication 205
New Developments in Roadway Machines 206
Color of Roadway Machines 211
Push Cars and Trailer Cars 213
Power and Bonding Drills 218
Discussion 727

Economics of Railway Labor 229
Analysis of Operations of Railways that Have Made Marked Progress in the Reduction of Labor Required in Maintenance of Way Work 230
Labor Economies to be Derived from Stabilization of Roadbed Through Means Other Than Drainage 233
Review and Revise Factors Previously Established for Equating Track Values for Labor Distribution 235
Labor Economies Possible Through the Use of Highway Motor Vehicles for Maintenance Forces 238
Labor Economies Resulting from Periodic Spot Welding of Rail Ends as Compared with Less Frequent Out-of-Face Welding 240
Labor Economies to Be Derived from Keeping Vegetation Out of Ballast 241
Discussion 691

Wood Bridges and Trestles 243
Specifications for Design of Wood Bridges and Trestles 244
Discussion 751

Masonry 257
Revision of Manual 258
Standard Specifications for Portland Cement 259
Standard Methods of Chemical Analysis of Portland Cement 262
Tentative Methods of Chemical Analysis of Portland Cement 280
Standard Methods of Sampling and Physical Testing of Portland Cement ... 285
Tentative Method of Test for Compressive Strength of Portland-Cement Mortars 300
Tentative Method of Test for Fineness of Portland Cement by Means of the Turbidimeter 305
Tentative Method of Test for Autoclave Expansion of Portand Cement 314
Specifications and Principles of Design of Plain and Reinforced Concrete 316
Progress in the Science and Art of Concrete Manufacture 317
Specifications for Foundations, Including Excavation, Cofferdam, Piling, Etc. .. 318
Bibliography on Foundations 318
Methods and Practices of Lining and Relining Tunnels 330
Specifications for Lining Railway Tunnels with Brick 331
Pressure Grouting 336
Grouting the Chicago Subway Tunnels 336
Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures 337
Specifications for Test Borings 355
Discussion 716

PAGE

Waterproofing of Railway Structures 357
Revision of Manual 357
Comparative Tests of Waterproofing Asphalts and Coal Tar Pitches 358
Discussion 710

Impact 360
Tests of Short Steel Spans with Open Floor, Together with Effect of Track Inequalities and Worn Wheels on Such Spans 361
Tests of Steel Spans with Ballasted Decks 361
Tests of Dynamic Shear in Steel Girders and Truss Spans 361
Analysis of Additional Data from Impact Tests 362
Determination of Damping Factors of Steel Spans and Variation in Amount of Damping with Change in Loading 362
Discussion 759

Iron and Steel Structures 363
Memoirs—Otis E. Hovey and Einar Weidemann 364
Revision of Manual 365
Specifications for Steel Railway Turntables 368
Rigid-Frame Design 374
Specifications for the Design of Rigid-Frame Steel Bridges 374
Discussion 737

Records and Accounts 379
Memoir—Henry Lehn 380
Revision of Manual 381
Bibliography on Subjects Pertaining to Records and Accounts 381
Office and Drafting Room Practices 383
Specifications of Materials to be Used for Drawings and Drafting 387
Recommended Practice to be Followed with Respect to Maintenance of Way Accounts and Statistical Requirements 387
Résumé of Developments of the Current Year in Connection with Regulatory Bodies and the Courts 389
ICC Valuation Orders, Reports and Records 392
Report Upon Changes In, Revisions and Interpretations of, ICC Accounting Classifications 393
Depreciation Accounting for Roadway Property 397
Discussion 700

Ties 399
Extent of Adherence to Specifications 399
Tie Renewals and Costs per Mile of Maintained Track 400
Investigate and Report on the Dimensions of Ties 401
Cause and Control of Splitting in Railroad Ties 401
Discussion 696

PAGE

Wood Preservation 405
Revision of Manual 406
Wood Preserving Fundamentals 407
Specifications for Treating Processes 408
Specifications for Creosote-Coal Tar Solutions 412
Wood Preserving Plant Practice 413
Service Test Records for Treated Ties 413
Report on Northern Pacific Test Tracks by C. N. Whitney 429
Destruction by Marine Organisms and Possible Ways of Prevention 435
Effect of Preservative Treatment by the Use of Creosote-Petroleum and Zinc Chloride and Petroleum 449
Destruction by Termites and Possible Ways of Prevention 461
Specifications for the Preservative Treatment of Pacific Coast Douglas Fir 462
Discussion 698

Roadway and Ballast 469
Physical Properties of Earth Materials—Structural Foundation Soils 471
Natural Waterways—Prevention of Erosion, Check Dams 474
Pipe Line Crossings—Specifications for Non-Inflammable Substances Under Pressure 481
Specifications for Perforated Pipe for Subdrainage 481
Specifications for Corrugated Metal Underdrain Pipe 482
Specifications for Multiplate or Sectional Plate Pipe and Arches 483
Vitrified Clay Pipe Culverts—Specifications 489
Effect of Locomotive Blow Offs on Track Maintenance 497
Retaining Structures 499
Tunnel Maintenance 507
Corrosion Resisting Fence Wire 509
Specifications for Wood Fence Posts 510
Special Ballast—Investigate the Use of Asphalt in Ballast 513
Discussion 731

Track 515
Revision of Manual 516
Plans and Specifications for Track Tools and Recommended Minimum Limits for Reclaimed Tools 519
Plans for Switches, Frogs, Crossings, Spring and Slip Switches 522
Specifications for Special Trackwork 525
Photoelastic Study of Stresses in Tie Plates 539
Design of Tie Plates for RE Rail Sections as Developed 547
Practicability of Using "Reflex" Units for Switch Lamps and Targets 548
Welding of Manganese Castings in Special Trackwork 549
Bolt Tension Necessary for Proper Supporting of Rail Joints 550
Prevention of Damage Due to Brine Drippings on Tracks and Structures 566
Specifications for High-Carbon Steel Track Spikes 570
Discussion 767

PAGE

Rail 573
Memoir—Grier Ralston Smiley 574
Revision of Manual 575
Rail Failure Statistics 576
Transverse Fissure Failures 582
Controlled-Cooled and Brunorized Rail 588
Cause and Prevention of Rail Battering and Methods of Reconditioning Rail Ends 591
Economic Value of Different Sizes of Rail 591
Continuous Welding of Rail 592
Service Tests of Various Types of Joint Bars 592
Investigate Joint Bar Failures and Give Consideration to the Revision of Design and Specifications 602
Corrugated Rail—Causes and Remedy 603
Development and Characteristics of Fractures Under Engine Burns in Rail 605
Discussion 704

Eighth Progress Report of the Joint Investigation of Fissures in Railroad Rails 607
Field Tests for Batter of End-Hardened Rails in Service 607
Laboratory Tests of Cracked End-Hardened Rails 613
Metallurgical Tests 617
Controlled-Cooled and Brunorized Rails in Service 625
Comparison of Drop and Bend Tests 626
Acknowledgments and Plans for Future 634
A Study of the Drop Test for Rails 635

PROCEEDINGS

President's Address 641
Report of Tellers 646
Address by Dr. H. J. Cody 652
Address by Andrew Stevenson 658
Address by Joseph B. Eastman 666
Reports of Secretary and Treasurer 671

MONOGRAPH

Influence of the Fatigue Strength of Structural Members Upon the Design of Steel Bridges by W. M. Wilson m1

MEMOIRS

Robert H. Ford m21
Grier Ralston Smiley m24

American Railway Engineering Association

CONSTITUTION

Revised to June 7, 1940

Article I

Name, Object and Location

1. Name

The name of this Association shall be the AMERICAN RAILWAY ENGINEERING ASSOCIATION.

2. Object

The object of the Association shall be the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways.

3. Means to be Used

The means to be used for this purpose shall be:

(a) The investigation of matters pertaining to the object of the Association through Standing and Special Committees.

(b) Meetings for discussion of reports and papers.

(c) The publication of papers, reports and discussions.

4. Conclusions

The conclusions reached shall be recommendatory.

5. Location

The office of the Association shall be located in Chicago, Illinois.

Article II

Membership

1. Classes

The membership of this Association shall be divided into five classes: Members, Life Members, Honorary Members, Associates and Junior Members.

2. Qualifications

A. General

(a) An applicant to be eligible for membership in any class other than that of Junior Member shall be not less than twenty-five (25) years of age.

(b) To be eligible for election to or retention of membership as a Member or an Associate, a person shall not be engaged directly and primarily in the sale to railways of appliances, supplies, patents or patented services.

B. Member

A Member shall be:

(a) An Engineer or Officer in the service or on the retired list of a railway corporation who has had not less than five (5) years' of experience in the location, construction, operation or maintenance of railways.

Graduation in engineering from a school of recognized standing shall be considered as equivalent to three (3) years of active practice, and the satisfactory completion of

each year of work in such school, without graduation, shall be considered as equivalent to one-half year of active practice.

(b) A Professor of Engineering in a university or college of recognized standing.

(c) An Engineer or Member of a public board or commission who in the discharge of his regular duties deals with railway problems.

(d) An Engineering Editor of a magazine which deals primarily with railway matters.

C. Life Member

A Life Member shall be a Member who has paid dues for thirty-five (35) years, or who has been retired under a recognized retirement practice and has paid dues for not less than twenty-five (25) years.

D. Honorary Member

(a) An Honorary Member shall be a person of acknowledged eminence in railway engineering or management.

(b) The number of Honorary Members shall be limited to ten (10).

E. Associate

An Associate shall be:

(a) An Engineer of a railway which is essentially an adjunct of an industry or which is used primarily to transport the products and materials of an industry to and from a railway which is a common carrier.

(b) A person qualified by training and experience to co-operate with Members in the object of this Association but who is not qualified to become a Member.

F. Junior Member

(a) A Junior Member shall be not less than twenty-one (21) years of age and shall be an engineering employee of a railway corporation who has had not less than three (3) years of experience in the location, construction, operation or maintenance of railways.

Graduation in engineering from a school of recognized standing shall be considered as equivalent to three (3) years of active practice, and the satisfactory completion of each year of work in such school without graduation, shall be considered as equivalent to one-half year of active practice.

(b) His membership in this Association shall terminate at the end of the calendar year in which he becomes thirty (30) years of age.

(c) He may make application for membership other than as a Junior Member at any time when he becomes eligible to do so.

3. Transfers

The Board of Direction shall transfer from one class of membership to another, or may remove from membership any person whose qualifications so change as to warrant such action.

4. Rights

(a) Members and Life Members shall have all the rights and privileges of the Association.

(b) Honorary Members shall have all the rights and privileges of the Association except those of holding elective office, provided, however, that Members or Life Members

who are elected Honorary Members shall retain all the rights and privileges of the Association.

(c) Associates and Junior Members shall have all the rights and privileges of the Association, except those of voting and holding elective office.

Article III

Admission, Resignation, Expulsion and Reinstatement

1. Charter Membership

The Charter Membership of this Association consists of all persons elected to membership before March 15th, 1900.

2. Application for Membership

(a) A person desirous of membership in this Association shall make application upon the form provided by the Board of Direction. In the event that Junior Membership is desired, the application shall so state.

(b) The applicant shall give the names of at least three Members of this Association to whom personally known. Each of such Members shall be requested by the Secretary of the Association to certify to a personal knowledge of the applicant with an opinion of the applicant's fitness or otherwise for membership.

(c) If an applicant is not personally known to three Members of this Association, the names of at least three well known persons engaged in railway or allied professional work to whom personally known shall be given instead. Each of such persons shall be requested by the Secretary of the Association to certify to a personal knowledge of the applicant with an opinion of the applicant's fitness or otherwise for membership.

(d) No further action shall be taken upon the application until replies have been received from at least three of the persons named by the applicant as references.

3. Election to Membership

(a) Upon completion of the application in accordance with Section 2 of this Article the Board of Direction through its Membership Committee shall consider the application and make such investigation as it may consider desirable or necessary.

(b) Upon completion of such consideration and investigation, each member of the Board of Direction shall be supplied with all the information obtained, together with the recommendation of the Membership Committee as to the class of membership, if any, to which the applicant is eligible and the admission of the applicant shall be canvassed by letter ballot among the members of the Board of Direction.

(c) In the event that an application has been made under the provisions of Section 2, Paragraphs (a) and (b) of this Article, a two-thirds affirmative vote of the entire Board of Direction shall be required for election.

(d) In the event that an application has been made under the provisions of Section 2, Paragraphs (a) and (c) of this Article, a unanimous affirmative vote of the entire Board of Direction shall be required for election.

4. Subscription to the Constitution

A person elected to membership in this Association shall subscribe to its Constitution on the form prescribed by the Board of Direction. If this provision has not been complied with within six months of notice of election the election shall be considered null and void.

5. Honorary Member

A proposal for Honorary Membership shall be endorsed by ten or more Members of the Association and a copy furnished each member of the Board of Direction. The

nominee shall be declared an Honorary Member upon receiving a unanimous vote of the entire Board of Direction.

6. Resignation

The Board of Direction shall accept the resignation, tendered in writing, of any person holding membership in the Association whose obligations to the Association have been fully met.

7. Expulsion

Charges may be preferred in writing by ten or more Members against a person holding membership in the Association. The person complained of shall be served with a copy of such charges and shall be given an opportunity to answer them to the Board of Direction. After such opportunity has been given, the Board of Direction shall take final action. A two-thirds affirmative vote of the entire Board of Direction shall be required for expulsion.

8. Reinstatement

(a) A person having been a Member, an Associate or a Junior Member of this Association and having resigned such membership while in good standing may be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

(b) A person having been a Member, an Associate or a Junior Member of this Association and having forfeited membership under the provisions of Article IV, Section 3, may, upon such conditions as may be fixed by the Board, be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

Article IV

Dues

1. Entrance Fee

(a) An entrance fee of ten dollars ($10.00) shall be payable to the Association with each application for membership other than Junior Membership. This sum shall be returned to an applicant not elected.

(b) No entrance fee shall be payable to the Association on account of Junior Membership.

2. Annual Dues

(a) The annual dues for each Member and each Associate shall be ten dollars ($10.00).

(b) The annual dues for each Junior Member shall be five dollars ($5.00).

(c) Life Members and Honorary Members shall be exempt from the payment of dues.

3. Arrears

A person whose dues are not paid before April 1st of the current year shall be notified by the Secretary. If the dues are still unpaid on July 1st further notice shall be given and a delinquent Member shall lose the right to vote. If the dues remain unpaid October 1st the person shall be notified on the form prescribed by the Board of Direction, and shall no longer receive the publications of the Association. If the dues are not paid by December 31st, the person shall forfeit membership without further action or notice, except as provided for in Section 4 of this Article.

4. Remission of Dues

The Board of Direction may extend the time of payment of dues, and may remit the dues of any Member, Associate or Junior Member who, for good reason, is unable to pay them.

Article V

Officers

1. Officers

(a) The officers of the Association shall be a President, two Vice-Presidents, nine Directors, a Secretary and a Treasurer.

(b) The President, the Vice-Presidents and the Directors, together with the five latest living Past-Presidents continuing to be Members, shall constitute the Board of Direction, in which the government of the Association shall be vested, and shall act as Trustees and have the custody of all property belonging to the Association. The President, the Vice-Presidents and the Directors shall be Members.

(c) The Secretary and the Treasurer shall be appointed by the Board of Direction.

2. Term of Office

The term of office of the President shall be one year, of the Vice-Presidents two years and of the Directors three years. The term of each shall begin at the close of the Annual Convention at which elected and continue until a successor is qualified. All other officers and employees shall hold office or position during the pleasure of the Board of Direction.

3. Officers Elected Annually

(a) There shall be elected at each Annual Convention a President, one Vice-President and three Directors.

(b) The candidates for President and for Vice-President shall be selected from the members or past members of the Board of Direction.

4. Conditions of Re-election of Officers

A President shall be ineligible for re-election. Vice-Presidents and Directors shall not be eligible for re-election to the same office until at least one full term has elapsed after the end of their respective terms.

5. Vacancies in Offices

(a) When a vacancy occurs in the office of President the duties shall be performed by the senior Vice-President.

(b) When a vacancy occurs in the office of either Vice-President the Board of Direction shall select a Vice-President from among the Directors. A Vice-Presidency shall not be considered vacant when one of the Vice-Presidents is filling a vacancy in the Presidency.

(c) A vacancy in the office of Director shall be filled by the Board of Direction.

(d) An incumbent in any office for an unexpired term shall be eligible for re-election to the office held; provided however, that anyone appointed to fill a vacancy as Director within six months after the term commences shall be considered as coming within the provisions of Article V, Section 4.

6. Vacation of Office

(a) When an elected officer ceases to be a Member of the Association, as provided in Article II, the office shall be vacated.

(b) In case of the disability of or neglect in the performance of duty by an officer, the Board of Direction, by a two-thirds affirmative vote of the entire Board, shall have the power to declare the office vacant.

Article VI

Nomination and Election of Officers

1. Nominating Committee

(a) There shall be a Nominating Committee composed of the five latest living Past-Presidents of the Association, who are Members, and five Members who are not officers.

(b) The five Members who are not officers shall be elected annually for a term of one year, when the officers of the Association are elected.

(c) The senior Past-President who is a member of the Committee shall be the Chairman of the Committee. In the absence of the senior Past-President from a meeting of the Committee the Past-President next in seniority present shall act as Chairman.

2. Method of Nominating

(a) Prior to December 1st of each year the Chairman shall call a meeting of the Committee at a convenient place, at which nominees for the various elective offices shall be selected as follows:

Office to be Filled	*Number of Candidates to be named by the Nominating Committee.*	*Number of Candidates to be elected at the Annual Election of Officers.*
President	1	1
Vice-President	1	1
Directors	9	3
Nominating Committee	10	5

(b) The Chairman of the Nominating Committee shall send the names of the nominees to the President and Secretary not later than December 15th of the same year, and the Secretary shall report them to the members of the Association on a printed slip not later than January 1st following.

(c) At any time between January 1st and February 1st any ten or more Members may send to the Secretary additional nominations for any elective office for the ensuing year signed by such Members.

(d) If any person nominated shall be found by the Board of Direction to be ineligible for the office for which nominated, or should a nominee decline such nomination, the name shall be withdrawn. The Board of Direction may fill any vacancies that may occur in the list of nominees up to the time the ballots are sent out.

3. Ballots Issued

Not less than thirty days prior to each Annual Convention, the Secretary shall issue a ballot to each voting member of record in good standing, listing the several candidates to be voted upon. When there is more than one candidate for any office, the names

shall be arranged on the ballot in the order that shall be determined by lot by the Nominating Committee. The ballot shall be accompanied by a statement giving for each candidate, his record of membership and activities in this Association.

4. Substitution of Names

Members may erase names from the printed ballot list and may substitute the name or names of any other person or persons eligible for any office, but the number of names voted for each office on the ballot must not exceed the number to be elected at that time to such office.

5. Ballots

(a) Ballots shall be placed in an envelope, sealed and endorsed with the name of the voter, and mailed to or deposited with the Secretary at any time previous to the closure of the polls.

(b) A voter may withdraw a ballot, and cast another, at any time before the polls close.

(c) Ballots not endorsed or from persons not qualified to vote shall not be counted.

(d) The ballots and envelopes shall be preserved for not less than ten days after the vote is canvassed.

6. Closure of Polls

The polls shall be closed at twelve o'clock noon on the second day of the Annual Convention, and the ballots shall be counted by tellers appointed by the Presiding Officer.

7. Election

(a) The persons who shall receive the highest number of votes for the offices for which they are candidates shall be declared elected.

(b) In case of a tie between two or more candidates for the same office, the Members present at the Annual Convention shall elect the officer by ballot from the candidates so tied.

(c) The Presiding Officer shall announce at the convention the names of the officers elected in accordance with this Article.

Article VII

Management

1. President

The President shall have general supervision of the affairs of the Association, shall preside at meetings of the Association and of the Board of Direction, and shall be ex-officio a member of all committees, except the Nominating Committee.

2. Vice-Presidents

The Vice-Presidents, in order of seniority, shall preside at meetings in the absence of the President and shall discharge the duties in case of a vacancy in the office.

3. Treasurer

The Treasurer shall receive all monies, deposit the same in the name of the Association, receipt to the Secretary therefor and invest all funds not needed for current disbursements as shall be ordered by the Board of Direction. The Treasurer shall pay all bills, when properly certified and audited by the Finance Committee, and make such reports as may be called for by the Board of Direction.

4. Secretary

The Secretary, shall be under the direction of the President and Board of Direction, the Executive Officer of the Association and shall attend the meetings of the Association and of the Board of Direction, prepare the business therefor, and duly record the proceedings thereof. The Secretary shall see that the monies due the Association are collected and without loss transferred to the custody of the Treasurer, and shall personally certify to the accuracy of all bills or vouchers on which money is to be paid. The Secretary is to conduct the correspondence of the Association, keep proper record thereof, and perform such other duties as the Board of Direction may prescribe.

5. Auditing of Accounts

The accounts of the Treasurer and of the Secretary shall be audited annually by an approved accountant under the direction of the Finance Committee of the Board of Direction.

6. Board of Direction

(a) The Board of Direction shall manage the affairs of the Association, and shall have full power to control and regulate all matters not otherwise provided in the Constitution.

(b) The Board of Direction shall meet within thirty days after each Annual Convention, and at such other times as the President may direct. Special meetings shall be called on request, in writing, of five members of the Board of Direction.

(c) Seven members of the Board of Direction shall constitute a quorum.

(d) At the first meeting of the Board of Direction after the Annual Convention, the following committees, each consisting of not less than three members, shall be appointed by the President from the Board of Direction and they shall report to and perform their duties under the supervision of the Board of Direction.

Finance
Publication
Outline of Work of Committees
Personnel of Committees
Membership
Manual

7. Duties of the Committees of the Board of Direction

(a) Finance Committee

The Finance Committee shall have immediate supervision of the accounts and financial affairs of the Association; shall approve all bills before payment, and shall make recommendations to the Board of Direction as to the investment of monies and other financial matters. The Finance Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money

other than the amounts necessary to meet ordinary current expenses of the Association, except by authority of the Board of Direction.

(b) Publication Committee

The Publication Committee shall have general supervision of the publications of the Association. The Publication Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money except by authority of the Board of Direction.

(c) Committee on Outline of Work of Committees

The Committee on Outline of Work of Committees shall prepare and present to the Board of Direction a report of the subjects to be investigated, considered and reported upon by the standing and special committees of the Association during the ensuing year.

(d) Committee on Personnel of Committees

The Committee on Personnel of Committees shall prepare and present to the Board of Direction a list of chairman, vice-chairmen and members of the standing and special committees of the Association for the ensuing year.

(e) Membership Committee

The Membership Committee shall make investigation of applicants for membership and shall make recommendations to the Board of Direction with reference thereto.

(f) Manual Committee

The Manual Committee shall study and recommend to the Board of Direction as to the manner in which the material adopted for addition or deletion from the Manual shall be handled.

8. Standing Committees

The Board of Direction may appoint standing committees to investigate, consider and report upon questions pertaining to railway location, construction, operation and maintenance.

9. Special Committees

The Board of Direction may appoint special committees to examine into and report upon any subject connected with the objects of this Association.

10. Discussion by Non-Members

The Board of Direction may invite discussions of reports from persons not members of the Association.

11. Sanction of Act of Board of Direction

An act of the Board of Direction which shall have received the expressed or implied sanction of the membership at the next annual convention of the Association shall be deemed to be the act of the Association.

Article VIII

Meetings

1. Annual Convention

(a) The Annual Convention of the Association shall be held in the City of Chicago, Illinois. The convention shall open on a Tuesday in the month of March to be determined by the President.

(b) The Secretary shall notify all members of the Association of the time and place of the Annual Convention at least thirty (30) days in advance thereof.

(c) The order of business at the Annual Convention of the Association shall be:

Reading of the Minutes of the last meeting
Address of the President
Reports of the Secretary and the Treasurer
Reports of Committees
Unfinished Business
New Business
Installation of Officers
Adjournment

(d) This order of business may be changed by a majority vote of Members present.

(e) The proceedings shall be governed by "Robert's Rules of Order" except as otherwise herein provided.

(f) Discussions shall be limited to members and to those others invited by the Presiding Officer to speak.

2. Special Meetings

Special meetings of the Association may be called by the Board of Direction and special meetings shall be so called by the Board of Direction upon written request of thirty Members. The request shall state the purpose of such meeting.

The call for such special meeting shall be issued not less than ten (10) days in advance and shall state the purpose and place of the meeting. No other business shall be taken up at such meeting.

3. Quorum

Twenty-five (25) Members shall constitute a quorum at all meetings of the Association.

Article IX

Amendment

1. Amendment

Proposed Amendment of this Constitution shall be made in writing, shall be signed by not less than ten Members and shall be acted upon in the following manner:

The amendment shall be presented to the Secretary, who shall send a copy to each member of the Board of Direction as soon as received. If a majority of the entire Board of Direction so votes the matter shall be submitted to the Association by letter-ballot.

The Board of Direction shall canvass the ballots which have been received within sixty days after the date of issue of the letter-ballot and if two-thirds (⅔) of the votes so received are in the affirmative the amendment shall be declared adopted and shall become immediately effective.

The result shall be announced at the next Annual Convention.

GENERAL INFORMATION

(Revised to March, 1941.)

GENERAL RULES FOR THE PREPARATION, PUBLICATION AND CONSIDERATION OF COMMITTEE REPORTS

(A) Appointment of Committees and Outline of Work

Standing Committees

1. The following are Standing Committees:

1. Roadway and Ballast.
3. Ties.
4. Rail.
5. Track.
6. Buildings.
7. Wood Bridges and Trestles.
8. Masonry.
9. Highways.
10. Signals and Interlocking.
11. Records and Accounts.
13. Water Service, Fire Protection and Sanitation.
14. Yards and Terminals.
15. Iron and Steel Structures.
16. Economics of Railway Location and Operation.
17. Wood Preservation.
18. Electricity.
20. Uniform General Contract Forms.
22. Economics of Railway Labor.
24. Cooperative Relations with Universities.
25. Waterways and Harbors.
26. Standardization.
27. Maintenance of Way Work Equipment.
28. Clearances.

Special Committees

2. Special Committees will be appointed from time to time, as may be deemed expedient, in the manner prescribed by Article VII, Section 9, of the Constitution.

The following are Special Committees:

Waterproofing of Railway Structures.
Impact.

Personnel of Committees

3. The personnel of all committees will continue from year to year, except when changes are announced by the Board of Direction. It is desirable that ten percent of the membership of each committee be changed each year.

Members of committees who do not attend meetings of committees during the year or render service by correspondence will be relieved and the vacancies filled by the Board at the succeeding annual convention.

Outline of Work

4. As soon as practicable after the reports of committees for the current year have been filed with the secretary, the Board of Direction will assign to the committees, subjects which in its judgment should preferably be considered during the succeeding year, provided, however, that such assignments may be subject to revision until the close of the Annual Convention. *Such assignments should not be deviated from except in extreme cases and then not until approved by the Committee on Outline of Work.*

(B) Preparation of Committee Reports

General

5. The objectives of the Association are advanced through the work of the committees in two ways—(1) the development of useful information pertinent to their assignments to be presented to the Association "as information", and (2) the formulation of recommended practices to be submitted for adoption and publication in the Manual.

(a) Whether the report on any particular assignment should take the form of "information" or a "recommended practice", depends largely on the nature of the assignment. Some assignments will be fulfilled completely by the presentation of information; others call for information in support of appended recommendations that are submitted for adoption. In still other cases, the primary objective is a comprehensive statement of recommended practices, but the development of these recommended practices may entail investigation or research work, the results of which are of such importance as to warrant their presentation as information prior to the submission of the recommendations. In some cases, also, it may be advisable to submit as information matter in the form of recommended practice, with a view to inviting suggestions and criticisms that may serve as the basis for revisions prior to the resubmission of the matter for adoption a year later.

Planning the Work

6. In pursuing the work on any assignment, the first step is necessarily one of fact finding, including (a) a study of available literature on the subject, particularly reports of previous investigations, (b) a compilation of current practice, especially recent changes in practice, and (c) resort to original tests or experimentation, after a canvass of all other sources of information indicates that research work is necessary.

Collection of Data

(a) Committees are privileged to obtain data or information in any proper way. If desired, the secretary will issue circulars of inquiry, which should be brief and concise. The questions asked should be specific and pertinent, and not of such general or involved character as to preclude the possibility of obtaining satisfactory and prompt responses. They should specify to whom answers are to be sent, and should be in such form that copies can be retained by persons replying either by typewriter or blueprint.

(b) Requests for appropriations for the conduct of research work should be sent to the secretary with a supporting statement setting forth: (a) the nature of the information sought; (b) how the railroads are adversely affected by the lack of this information; (c) the estimated cost of the investigation; (d) the estimated time to complete the work; (e) the basis for assuming that the investigation will produce the data desired; and, (f) an estimate of the savings to be realized or other advantages to accrue from the successful completion of the investigations. A request for funds to continue or complete an investigation shall include a statement of the results obtained to date.

Reports

7. Committees should pursue their investigations on all assignments but are expected to present progress or final reports for publication only on those assignments regarding which pertinent information has been developed.

(a) Committees are privileged to present the results of any special study or investigation they may be engaged upon in connection with their assignments that may be considered of sufficient importance to warrant presentation.

(b) Reports of information, supplementing previous reports of progress, may include a brief review of matter previously presented, but should avoid extended repetition of such matter.

(c) Matter offered for adoption and publication in the Manual should be submitted in full, regardless of its publication in previous years unless the matter being offered appeared in identical form not more than one year before being submitted for adoption.

(d) Illustrations accompanying reports should, when possible, be prepared so that they can be reproduced on one page. The use of inserts should be avoided.

(e) One of the most important duties of each committee is to examine its own subject-matter in the Manual each year and submit such revisions of or supplements to the Manual as are deemed necessary to keep it up to date. New matter for publication in the Manual and revisions thereof must be submitted in the form and manner specified in the General Rules for Publication of the Manual.

Form of Reports

8. Committee reports shall be prepared in accordance with the Instructions published in the annual pamphlet of committee assignments and personnel.

(C) Publication of Reports

Dates for Filing and Publication of Reports

9. For the convenience of those attending the convention, the reports of committees to be presented at any session of the annual convention will be published, so far as possible, in the same bulletin. To carry out this plan requires a careful scheduling of the filing of reports and the publication of bulletins, and the arrangement of the convention program. It is of utmost importance that chairmen file complete reports of their committees on or before the dates specified on the schedule furnished them.

Written Discussions

10. Written discussions of published reports will be transmitted to the chairman of the interested committee who will read or present them by title or in abstract at the convention. Written discussions will be published in the Proceedings as a part of the discussion of the committee reports.

Verbal Discussions

11. Each speaker's remarks will be submitted to him in writing before publication in the Proceedings, for the correction of diction and errors of reporting, but not for the elimination of remarks.

(D) Consideration of Committee Reports

Sequence

12. The sequence in which committee reports will be considered by the convention will be determined by the Board of Direction.

Method

13. Reports offered as information will be presented by title or by a brief outline of the contents. Comments or criticisms may be offered from the floor upon invitation from the presiding officer.

14. Matter submitted for adoption and publication in the Manual may receive consideration by one of the following procedures:

(a) Reading by title.
(b) Reading, discussing and acting upon each conclusion separately.
(c) By majority vote, discussion will be had on each item. Clauses not objected to when read will be considered as voted upon and adopted.

Action on Reports

15. No formal action is to be taken by the convention on matter submitted as information, whether in the form of a progress or final report.

Action on matter submitted for adoption and publication in the Manual will be one of the following:

(a) Adoption as a whole as presented.
(b) Affirmative action on the amendment of a part or parts of the matter presented, followed by adoption as a whole, as amended.
(c) Adoption of a part, complete in itself, and referring of remainder back to the committee.
(d) Recommittal with or without instructions.

NOTE.—An amendment which affects underlying principles, if adopted, shall of itself constitute a recommittal of such part of the report as the committee considers affected.

The Chair will decline to entertain amendments which in his opinion are primarily a matter of editing.

(E) PUBLICATION OF ABSTRACTS BY TECHNICAL JOURNALS

The following rules will govern the releasing of matter for publication in technical journals:

Committee reports, requiring action by the Association at the annual convention, will not be released until after presentation to the convention; special articles, contributed by members and others, on which no action by the Association is necessary, are to be released for publication by the technical journals after issuance in the bulletin; provided, application therefor is made in writing and proper credit be given the Association, authors or committees presenting such material.

GENERAL RULES FOR PUBLICATION OF THE MANUAL

Title

1. The title of the volume will be "Manual of the American Railway Engineering Association."

2. The Board of Direction shall have the authority to withhold from publication any matter which it shall consider as not desirable to publish, or as not being in proper shape, or as not having received proper study and consideration.

Contents

3. The matter adopted by the Association for publication in the Manual shall be considered Recommended Practice, but shall not be binding on the members. Recommended Practice, as defined by the Board of Direction (May 20, 1936) is a material, device, plan, specification or practice recommended to the railways for use as required, either exactly as presented or with such modifications as may be necessary or desirable to meet the needs of individual railways, but in either event, with a view to promoting efficiency or economy, or both, in the location, construction, operation or maintenance of railways.

Requisites for Adoption

4. The Manual will include only such matter as has been made the subject of a special study by a standing or special committee and embodied in a committee report, published not less than thirty days prior to the Annual Convention, and submitted by the committee to the Annual Convention, and which, after due consideration and dis-

cussion, shall have been voted on and formally adopted by the Association. Subjects which, in the opinion of the Board of Direction shall be reviewed by the Association of American Railroads, may be referred to that association before being published in the Manual.

5. All conclusions included in the Manual must be in concise and proper shape for publication, as the Manual will consist only of a summary record of the definitions, specifications and principles of practice adopted by the Association, with a brief reference to the published Proceedings of the Association for the context of the committee report and subsequent discussion and the final action of the Association.

Revision

6. Any matter published in the Manual may be amended or withdrawn by vote at any subsequent Annual Convention, provided such changes are proposed in time for publication not less than thirty days prior to the Annual Convention, and in the following manner: (a) upon recommendation of the committee in charge of the subject; (b) upon recommendation of the Board of Direction; (c) upon request of five members, made to the Board of Direction.

7. Revisions of or additions to the Manual authorized by action at each convention will be published annually in the form of loose-leaf sheets which will be made available to all holders of the Manual. These supplemental sheets will be accompanied by instructions for insertion of the new sheets and the withdrawal of sheets that have been superseded, as well as those that have been withdrawn by action of the Association.

Report of Committee 26—Standardization

F. L. Nicholson,
Chairman,
J. E. Armstrong
W. G. Arn
J. E. Bernhardt
F. L. C. Bond
A. E. Botts
J. G. Brennan
H. F. Brown
B. W. DeGeer
H. R. Duncan
John Foley
R. P. Hart
J. B. Hunley
C. A. Knowles
L. H. Laffoley
J. A. Lahmer
J. F. Leonard
H. G. Morgan
C. H. Mottier
W. G. Nusz
G. M. O'Rourke
G. P. Palmer
W. H. Penfield
H. M. Stout
G. R. Westcott
A. R. Wilson
Committee

To the American Railway Engineering Association:

Your committee respectfully reports on the following assignments:

1. What AREA recommended practices should be advocated for general use on railways.

Your committee submitted a tabulation of recommended practices thought adaptable to general use on railways in the interest of uniformity of practice, economy and efficiency, at the convention in 1937 and again in 1940, and because of general conditions now affecting materials and labor, we most earnestly ask favorable consideration for adoption, if it has not already been done, of the recommended practices listed in Appendix A.

2. What AREA recommended practices should be sponsored as subjects for national standardization.

Two projects are recommended by Committee 14—Yards and Terminals—now accepted and appearing in the AREA Manual, viz.:

Specifications for the Manufacture and Installation of Four-Section, Knife Edge, Railway Track Scales (Manual page 14–47);
Specifications for the Manufacture and Installation of Two-Section, Knife Edge, Railway Track Scales (Manual page 14–67).

These were thought suitable subjects for National Standardization as far back as 1935. The specifications under consideration at that time had been prepared by a committee representing the AAR, AREA, National Bureau of Standards, the Railroad and Warehouse Commission of Minnesota, the National Scale Men's Association and the Scale Manufacturers Association. Committee 26, in its report of that date, stated, "It is considered to be advantageous to have these specifications approved by the American Standards Association", but shortly thereafter Committee 14 concluded that the specifications referred to needed a complete overhauling and requested that further action be held in abeyance until consideration could be given. The revisions then thought necessary have been completed and the specifications now in the Manual have been approved by the National Bureau of Standards and are now ready for sponsoring by the AREA for national standardization.

3. Maintain contact with standardization bodies and keep the Association informed on important matters developed by such contact.

Your committee presents herewith—

(a) A list of representatives of the Association of American Railroads serving on Council of the American Standards Association and on its Correlating and Advisory Committees—Appendix B.

(b) A list of technical projects on which the Association of American Railroads is now cooperating with the American Standards Association, through representatives of the Construction and Maintenance and Electrical Sections of the Engineering Division—Appendix C.

(c) A list of collaborating representatives of the American Railway Engineering Association on committees of the American Society for Testing Materials—Appendix D.

(d) A summary of the activities of the American Society for Testing Materials during the year 1941 of special interest to railways—Appendix E.

(e) A summary of the activities of the Canadian Engineering Standards Association during the year 1941 of special interest to railways—Appendix F.

The information concerning the American Standards Association, the American Society for Testing Materials and the Canadian Engineering Standards Association was furnished by the secretaries of the respective organizations.

This report is submitted as information.

The Committee on Standardization,
F. L. Nicholson, *Chairman.*

Appendix A

Tabulation of Specifications and Recommended Practices as Contained in the Manual That Are Presented for Uniform Practice on All Railroads

The following items have been selected from the material adopted by the Association as recommended practices and printed in the Manual as worthy of adoption on all railroads in the interest of economy and efficiency. The list is set up in subdivisions conforming to standing committee numbers. A similar list was presented in 1940 and it is now thought wise to bring this matter to your attention again.

1—Roadway

Item	*Manual Reference*
Specifications for Cast Iron Pipe Culverts	1– 12–12.1
Specifications for Corrugated Metal Culverts	1– 13
Specifications for Pipe Line Crossings Under Railway Tracks	1– 25
Specifications for the Formation of the Roadway	1– 27
Specifications for Construction, Excavation and Temporary Lining of Tunnels	1– 66.1
Specifications for Concrete Fence Posts	1– 67
Specifications for Metal Fence Posts	1– 71
Specifications for Standard Right-of-Way Fences	1– 73

2—Ballast

Item	*Manual Reference*
Specifications for Stone Ballast	2– 1
Specifications for Prepared Gravel Ballast	2– 7
Specifications for Prepared Blast Furnace Slag Ballast	2– 13
Ballast Sections	2– 17–18–19–20–21–22

3—Ties

Specifications for Crossties	3– 1
Specifications for Switch Ties	3– 11
Methods and Practices for Proper Seasoning of Ties, etc.	3– 16.2
Specifications for Tie Plugs	3– 21
Specifications for Dating Nails	3– 23
Anti-Splitting Devices	3– 25

4—Rail

Standard Specifications for Open-Hearth Steel Rails	4– 1
Standard Rail Sections, 90-lb., 100-lb., 112-lb., and 131-lb.	4– 7
Drilling of Rails	4– 12
Standard Locations for Tension Test Specimens and for Boring for Chemical Analyses	4– 13
Recommended Practice for Rail Inspection	4– 13
Specifications for High Carbon Steel Joint Bars	4– 17
Specifications for Quenched Carbon Steel Joint Bars	4– 21
Joint Bars and Assemblies for 90-lb., 100-lb., 112-lb., and 131-lb. Rail	4– 24
Specifications for Heat Treated Carbon Steel and Alloy Steel Track Bolts	4– 29
Design for Track Bolts	4– 33
Specifications for Spring Washers	4– 37
Specifications for Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types	4– 57
Girder Rail Sections	4– 63
Joint Bars for 128-lb. and 159-lb. Girder Rail	4– 68

5—Track

AREA Portfolio of Trackwork Plans	
Specifications for Steel Tie Plates	5– 1
Design of Tie Plate for RA–A and RE Rail Sections	5– 5
Specifications for Wrought Iron Tie Plates	5– 11
Specifications for Hot Worked, High Carbon Steel Tie Plates	5– 14.1
Specifications for Soft Steel Cut Track Spikes	5– 15
Design of Cut Track Spike	5– 16.2–17
Specifications and Plans for Track Tools	5– 47

6—Buildings

Specifications for Buildings for Railway Purposes	6– 1

7—Wood Bridges and Trestles

Item	*Manual Reference*
Specifications for Wood Piles	7– 1
Specifications for Workmanship for Pile and Framed Trestles of Untreated Material to be Built Under Contract	7– 7
Specifications for Structural Timbers	7– 17

8—Masonry

Specifications for Portland Cement Concrete, Plain and Reinforced	8– 1
Specifications for Rigid Frame Concrete Bridges	8– 73.1
Specifications for Making Precast Concrete Piles	8– 87
Specifications for Driving Precast Concrete Piles	8– 89
Specifications for Reinforced Concrete Culvert Pipe	8– 90
Specifications for Shotcrete	8– 95
Specifications for Repairing Deteriorating Concrete	8– 99
Specifications for Lining Railway Tunnels with Plain Concrete	8–103
Specifications for Stone Masonry	8–109

9—Highways

Specifications for Preparation of Track Structure, Width of Crossing and Approaches for Construction of Street Crossings Over Railway Track	9– 3
Specifications for the Construction of Bituminous Crossings	9– 5
Specifications for the Construction of Rail Type Street Crossings	9– 9
Specifications for Construction of Precast Concrete Slab Crossings	9– 12.1
Specifications for Construction of Monolithic Concrete Crossings	9– 12.5
Highway Crossing Signs and Signals (Bulletin No. 2 AAR)	9– 17

13—Water Service, Fire Protection and Sanitation

Specifications for Cast Iron Pipe and Special Castings	13– 15
Specifications for Wood Water Tank	13– 21
Specifications for Steel Water and Oil Tanks	13– 37
Specifications for Soda Ash to be Used in Water Treatment	13– 43
Specifications for Hydrated Lime to be Used in Water Treatment	13– 45
Specifications for Quicklime to be Used in Water Treatment	13– 47
Specifications for Sulphate of Alumina to be Used in Water Treatment	13– 49
Specifications for Sulphate of Iron to be Used in Water Treatment	13– 51
Specifications for Salt to be Used in Regeneration of Zeolite Water Softening Plants	13– 55

14—Yards and Terminals

Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales	14– 33
Specifications for the Manufacture and Installation of 4-Section, Knife-Edge Railway Track Scales	14– 47
Specifications for the Manufacture and Installation of 2-Section, Knife-Edge Railway Track Scales	14– 67

Item	*Manual Reference*
Specifications for the Manufacture and Installation of Motor Truck, Built-In, Self-Contained and Portable Scales for Railway Service	14– 85
Large-Capacity Scales—Tolerances, SR Requirements and Regulations	14–107

15—Iron and Steel Structures

Specifications for Steel Railway Bridges	15– 1
Specifications for Movable Railway Bridges	15– 49
Requirements for the Protection of Traffic at Movable Bridges	15– 93
Specifications for Steel Railway Turntables	15–109
Instructions for the Mill Inspection of Structural Steel	15–115
Instructions for the Inspection of the Fabrication of Steel Bridges	15–116
Instructions for the Inspection of Bridge Erection	15–118
Classification of Railway Bridges	15–119
Rules for Rating Existing Iron and Steel Bridges	15–121

17—Wood Preservation

Specifications for Treating Processes	17– 5
Specifications for Preservatives	17– 13
Specifications for Preservative Treatment of Douglas Fir	17– 47
Specifications for Treatment of Air-Seasoned Douglas Fir	17– 57

20—Uniform General Contract Forms

Form of Construction Contract	20– 1
Form of Cost-Plus Percentage Construction Contract	20– 11
Forms of Agreement for:	
Organization and Operation of a Joint Passenger Terminal Project	20– 21
Joint Use of Passenger Station Facilities	20– 47
Joint Use of Freight Terminal Facilities	20– 53
Interlocking Plant	20– 61
Trackage Rights	20– 67
Industry Track	20– 73
Crossing of Railways at Grade	20– 81
Purchase of Electrical Energy for Other Than Traction Purposes	20–101
Use of Railway Property by High Pressure Pipe Lines With Special Reference to Pipe Lines Carrying Inflammable Oils and Gas	20–105
Joint Use of Poles on Railway Lands	20–109
Wire or Cable Line Crossings	20–112.1
Pickup and Store Door Delivery	20–124.1
Unloading Liquefied Petroleum and Other Gasses	20–133

27—Work Equipment

Standardization of Parts and Accessories for Railway Maintenance Motor Cars	27– 1

28—Clearances

Item	*Manual Reference*
Clearances	Cl– 1
Clearance Diagrams for:	
Bridges	Cl– 2
Turntables	Cl– 3
Single-Track Tunnel	Cl– 4
Double-Track Tunnel	Cl– 5
Buildings and Sheds Adjacent to Side Tracks	Cl– 6
Warehouse and Engine House Doors	Cl– 7
Platforms	Cl– 8
Equipment, Unrestricted	Cl– 9
Equipment, Unrestricted for Main Lines	Cl– 10

Waterproofing of Railway Structures

Specifications for Membrane Waterproofing	Wpfg– 1
Specifications for Bituminous Emulsions for Dampproofing	Wpfg– 17

Appendix B

Representation of the Association of American Railroads on the Standards Council of the American Standards Association 1941–1942–1943

Principals	*Term Expires*
A. R. Wilson (Engineering Division)	Dec. 31, 1942
W. A. Jackson (Operating Division)	Dec. 31, 1943
J. E. Ennis (Mechanical Division)	Dec. 31, 1941

Alternates

K. Cartwright (Mechanical Division)
W. F. Cummings (Engineering Division)
E. M. Hastings (Engineering Division)
E. K. Post (Signal Section)
A. L. Sorensen (Purchases and Stores Division)
Sidney Withington (Electrical Section, Engineering Division)
J. D. Rogers (Operating–Transportation Division)

Representation of the Association of American Railroads on Correlating and Advisory Committees of the American Standards Association

Committee	*AAR Division*	*Representatives*
Electrical Standards Committee and U. S. National Committee of the IEC	IV Eng. Electrical Section	Sidney Withington
Highway Traffic Standards Committee		J. G. Brennan
Mechanical Standards Committee	V Mech.	J. E. Ennis Alt. K. Cartwright
Safety Code Correlating Committee		C. E. Hill

Appendix C

American Standards Association Technical Projects on Which the Association of American Railroads Is Now Cooperating Through Representatives of the Construction and Maintenance and Electrical Sections—Engineering Division

	ASA Project	*Committee or Section*	*Representatives*
A 1	Portland Cement, Specifications for	Com. 8—Masonry	Meyer Hirschthal J. F. Leonard C. P. Marsh
A21	Cast Iron Pipe and Special Castings	Com. 13—Water Service, Fire Protection and Sanitation	C. R. Knowles
A22	Walkway Surfaces, Safety Code for	Com. 6—Buildings	W. T. Dorrance
A35	Manhole Frames and Covers	Com. 14—Yards and Terminals Com. 6—Buildings	H. L. Ripley Alt. J. R. W. Ambrose Alt. W. T. Dorrance
A36	Rating of Rivers	Elec. Sec.	R. J. Needham
B 1	Screw Threads, Standardization and Unification of	Com. 4—Rail	C. B. Bronson
B16	Pipe Flanges and Fittings	Com. 13—Water Service, Fire Protection and Sanitation	C. R. Knowles
B18	Bolt, Nut and Rivet Proportions	Com. 4—Rail Com. 5—Track Com. 15—Iron and Steel Structures	C. B. Bronson Alt. J. B. Myers O. E. Selby
B20	Conveyors and Conveying Machinery, Safety Code for	Com. 14—Yards and Terminals	H. G. Dalton
B27	Plain and Lock Washers	Com. 5—Track	E. W. Caruthers
B30	Cranes, Derricks and Hoists, Safety Code for	Com. 27—Maintenance of Way Work Equipment	C. L. Fero Alt. T. M. Pittman
B33	Hose Coupling Screw Threads	Com. 13—Water Service, Fire Protection and Sanitation	W. L. Curtiss Alt. J. P. Hanley
B36	Dimensions and Materials of Wrought Iron and Wrought Steel Pipe and Tubing, Standardization of	Com. 13—Water Service, Fire Protection and Sanitation	J. J. Laudig
C 1	Electric Wiring and Apparatus in Relation to Fire Hazard. Regulations for (National Electrical Code)	Elec. Sec.	M. A. Pinney Alt. G. L. Sealey
C 2	National Electrical Safety Code	Elec. Sec.	Sidney Withington
C 8	Wires and Cables Insulated (Other than Telephone and Telegraph)	Elec. Sec.	C. R. Troop
C8k2	Heat Resisting Wires	Elec. Sec.	J. L. Minick
C11	Hard Drawn Aluminum Conductors	Elec. Sec.	K. H. Gordon
C29	Insulators for Electric Power Lines	Elec. Sec.	H. F. Brown
C34	Mercury Arc Rectifiers	Elec. Sec.	J. S. Thorp
C37	Power Switchgear	Elec. Sec.	S. R. Negley
C42	Definitions of Electrical Terms	Elec. Sec.	J. H. Davis
C52	Electric Welding Apparatus	Elec. Sec. Const. & Maint. Sec.	R. P. Winton R. P. Winton
C57	Transformers	Elec. Sec.	S. R. Negley
C59	Electrical Insulating Materials in General	Elec. Sec.	C. R. Troop
C60	Vacuum Tubes for Industrial Purposes, Standardization of	Elec. Sec.	J. H. Davis
C63	Radio-Electrical Coordination	Elec. Sec.	J. H. Davis
E12	Loading Platforms at Freight Terminals and Warehouses	Com. 6—Buildings	A. R. Wilson Alt. W. T. Dorrance
G 8	Zinc Coating of Iron and Steel, Specifications for	Com. 13—Water Service, Fire Protection and Sanitation	J. J. Laudig
H 4	Copper Wire, Specifications for	Elec. Sec.	J. L. Minick
O 3	Crossties and Switch Ties, Specifications for	Com. 3—Ties	John Foley
O 4	Wood, Methods of Testing	Com. 6—Buildings	W. T. Dorrance
O 5	Wood Poles, Specifications for	Elec. Sec.	Paul Lebenbaum
Z 4	Industrial Sanitation, Safety Code for	Com. 13—Water Service, Fire Protection and Sanitation	R. C. Bardwell
Z 5	Ventilation Code	Com. 6—Buildings	W. T. Dorrance
Z11	Petroleum Products and Lubricants	Const. & Maint. Sec.	J. G. Hartley
Z14	Drawings and Drafting Room Practice (Exclusive of Architectural Drawings), Standards for	Com. 11—Records and Accounts	D. C. Teal
Z15	Graphic Presentation, Standards for	Com. 11—Records and Accounts	D. C. Teal
Z23	Sieves for Testing Purposes, Specifications for	Com. 8—Masonry	Meyer Hirschthal
Z28	Work in Compressed Air	Com. 8—Masonry	J. J. Yates

Appendix D

Collaborating AREA Representatives on Committees American Society for Testing Materials

A–1 on Steel

4. E. E. Chapman
13. Ray McBrian
15. A. W. Carpenter

A–5 on Corrosion of Iron and Steel

1. A. R. Jones
13. Ray McBrian
15. A. W. Carpenter

B–2 on Non-Ferrous Metals and Alloys

1. A. R. Jones

B–5 on Copper and Copper Alloys, Cast and Wrought

15. C. H. Mercer

C–1 on Cement

8. M. Hirschthal
8. C. P. Marsh
8. J. F. Leonard

C–4 on Clay Pipe

1. W. C. Swartout

C–9 on Concrete and Concrete Aggregates

8. C. P. Marsh
8. M. Hirschthal

C–12 on Mortars for Unit Masonry

8. W. M. Ray

C–13 on Concrete Pipe

8. Theodore Doll
8. J. F. Leonard
15. G. A. Haggander

D–7 on Timber

7. C. J. Hogue
7. J. A. Newlin
17. Herman von Schrenk

D–8 on Bituminous Waterproofing and Roofing Materials

Wpfg. J. A. Lahmer

D–19 on Water for Industrial Use

13. R. C. Bardwell
13. J. J. Laudig

Note—Numbers in front of names designate AREA committees.

Appendix E

Work of the American Society for Testing Materials in National Defense of Particular Interest to Railroad Engineers

Steel

Of predominant interest at this time is the development under the auspices of the OPM of a series of National Emergency Steel Specifications, this work being organized by the ASTM., the SAE., and the AISI., with the collaboration of the War and Navy departments, and the cooperation of other bodies. The goal is to establish as promptly as possible a selected list of steel specifications, to be designated National Emergency Steel Specifications, which, in effect, involves the selection of the minimum number of steel specifications, compositions and sections necessary to meet the requirements of National Defense, both direct and indirect.

It is believed that the productive capacity of the steel industry, and of the manufacturing industries using steel for defense equipment, can be materially increased within present facilities by concentration of production upon a reduced number of steels, particularly with respect to alloy steels. Consideration will necessarily be given to non-defense requirements for steel in establishing the list of National Emergency Steel Specifications.

It is the intention of the OPM, through its Iron and Steel Section, to use the list as an aid in administering steel priorities and allocations.

A number of technologists from the railroad industry will be asked to assist in the work of several technical committees which are being organized. Mr. C. L. Warwick, consultant, OPM, and secretary–treasurer of ASTM., is head of the Administrative Committee.

During 1941 an important development was the publication of new Tentative Specifications for Low-Alloy Structural Steel (A 242 — 41 T) which covers material characterized by relatively high yield points suitable for welding or riveting construction. A number of alloys in this general classification have been introduced in the past several years and it was felt particularly by structural steel interests that a standard specification would be helpful.

Another new specification, essentially a revision of an existing standard, is the one covering Carbon Steel and Alloy Steel Blooms, Billets and Slabs for Forgings (A 248 — 41 T). A study intended only to modernize two or three of the compositions involved, resulted in a decision to completely overhaul the specification and modernize many of the requirements, in particular, the chemistry. Since this specification is basic in the forging group and covers a wide range of applications, including railroad, industrial, and ordnance and others, the approval of the new specification as tentative was felt to be a real accomplishment. Mr. Ray McBrian, engineer of standards and research of the Denver & Rio Grande Western Railroad, a member of AREA Committees 4 and 13, was particularly active in the various stages of this work.

Since the ASTM had had no standardized requirements for structural quality flat hot-rolled steel, commonly called sheet steel, Committee A–1 was pleased to report on the two specifications covering essentially the same quality of material but in different gages, A 245 — 41 T (0.2499 and 0.1874 to 0.0478 in. in thickness), and A 246 — 41 T (0.0477 to 0.0225 in. in thickness).

Other new specifications cover Carbon Steel and Alloy Steel Ring and Disk Forgings (A 243 — 41 T) and Heat-Treated Wrought Steel Wheels (A 244 — 41 T). In the development of both these specifications, railroad interests were active.

Cast Iron

The new Recommended Practice for Evaluating the Microstructure of Graphite in Gray Iron (A 247 — 41 T) which was developed in cooperation with the American Foundrymen's Association is probably the outstanding achievement in this field.

Copper and Copper Alloys, Cast and Wrought

The work of Committee B–5 on Copper and Copper Alloys, Cast and Wrought, is tied in directly with national defense efforts. This committee probably has more projects of importance in this respect than any other ASTM group. Completed during 1941 were a series of seven new specifications covering copper base alloys for sand castings. This was a simplification effort to reduce the number of compositions to the minimum practicable limit. Other new standards provide requirements for Manganese Bronze Rods, Bars, and Shapes (B 138), Phosphor Bronze Rod (B 139), Leaded Red Brass Rods, Bars, and Shapes (B 140), Aluminum Bronze Rods, Bars, and Shapes (B 150), Copper-Nickel-Zinc Alloy Rod and Wire (B 151), Phosphor Bronze Wire (B 159).

Two very important new tests were standardized after extensive research work involving the Mercurous Nitrate Test (B 154 — 41 T) and the Test for Expansion (Pin Test) (B 153 — 41 T). The former is an accelerated corrosion test for determining in copper or copper-base alloy products or assemblies the presence of applied or residual stresses which might bring about failure of the material in service or storage through stress corrosion or season cracking.

Cement

In this field the adoption as standard of the previously issued tentative specifications for Portland cement was of most interest. This specification provides requirements for five types some of which were covered previously in separate specifications, including the standards for Portland cement, high-early strength, low heat of hydration, and high sulphate resistance.

Fire Tests of Concrete, Mortars and Masonry Units

After considerable work in committee C–5 on Fire Tests of Materials and Construction based on an extensive report by Professor W. J. Krefeld of Columbia University, a standardized test for fire-retardent properties of wood was approved by the ASTM. This is a modification of the so-called "crib test".

New tentative specifications for ready-mixed concrete (C 94), essentially revisions of the existing standard, but which take cognizance of important developments in this field, should be noted.

The specifications for building brick (clay or shale) (C 62) have been revised by the inclusion of an extended prefatory statement discussing the basis of the specifications, reasons for selecting the physical properties required, and related information; also some changes were made in the physical properties.

Thermal Insulating Materials

First ASTM standards in this field for which a new committee was organized a few years ago were approved. These requirements cover sampling and preparation of specimens (C 163 — 41 T), tests for bulk density (C 164), compressive strength and flexural

strength of preformed block type (C 165), covering capacity and volume change upon drying (C 166), thickness and density of blanket type (C 167). Also definitions of terms relating to thermal insulating materials (C 168).

Hardness Test, Low Temperature Properties of Metals

Because of difficulties encountered in certain defense work, including some of the British purchasing problems, the ASTM's Section on Indentation of Hardness is beginning an intensive study in an effort to develop data on comparative hardness values of Rockwell, Brinell, and Vickers tests. It is apparent to this group of experts that no table of comparative values can cover all metal and alloys. From the information available, discrepancies were particularly apparent in ranges below 200 Brinell. It is felt, however, that relations can be developed for each commonly used metal or alloy. The committee is now developing such tables for certain materials including cartridge brass.

The Joint Research Committee on Effect of Temperature on the Properties of Metals completed its report, under way for almost two years, on the impact of values and tensile properties of metals at subatmospheric temperatures. This very extensive report is the first comprehensive summary of available data since H. W. Russell's paper published in the ASTM 1931 Symposium on Effect of Temperature on the Properties of Metals—Mr. Russell's paper being the only extensive summary since Hatfield's report about 1906. The increasing use of metals at low temperatures makes this report a particularly pertinent one. Service branches of the U. S. Government and others have been much interested in it.

Appendix F

Summary of the Activities of the Canadian Engineering Standards Association During 1941 of Special Interest to Railways

During the year the Canadian Engineering Standards Association published 26 new standards or revisions to existing standards, as follows:

Section A—Civil Engineering

A–54—1940—Procedure for Fire Tests on Building Construction and Materials

Section B—Mechanical Engineering

B–29—1940—Machine Screws and Nuts (3rd edition)
B–62—1940—Welded Genuine Wrought Iron Pipe
B–64—1940—Copper and Brass Pipes, Standard Sizes
B–65—1940—Wood Screws
B–66—1940—Copper Water Tubes

Section C—Electrical Engineering

C–15(A)—1940—Eastern White Cedar Poles (2nd edition)
C–15(B)—1940—Western Red Cedar Poles
C–15(C)—1940—Red, Jack and Lodgepile Pine Timber for Poles and Reinforcing Stubs
C–15(D)—1940—Creosote Treatment for Pine Poles, etc.
C–68(A)—1940—Paper-Insulated Lead-covered Cable

Canadian Electrical Code, Part II (Approvals) Specifications:

C 22.2 No. 1(A)—1940—Power Operated Radio Devices, Inductively-Coupled (Transformer) Type (2nd edition)
16 —1940—Insulated Conductors for Power-Operated Radio Devices
35 —1940—Extra Low Potential Control-Circuit Wire and Cable
47 —1940—Air-Cooled Transformers (Dry Type)
51 —1941—Armoured Cable and Armoured Cord
52 —1941—Service Entrance Cables
57 —1940—Pull-off Plugs for Electro-Thermal Appliances
69 —1940—Porcelain Cleats, Knobs and Tubes

Canadian Electrical Code, Part III, Outside Wiring Rules:

C 22.3 No. 1(A)—1940—Supply and Trolley Lines Crossing Railways
1(B)—1940—Communication Lines Crossing Railways

Section S—Steel Construction

S–16—1940—Steel Structures for Buildings (3rd edition)
S–59—1940—Metallic Arc Welding (Bridges and Buildings)
S–61—1940—Cast Iron
S–69—1941—Welders' Helmets, Hand Shields and Goggles and General Purpose Anti-Glare Goggles.

The foregoing specifications have been prepared with the cooperation and approval of both manufacturing and purchasing interests, and of trade associations, educational institutions, the railways, insurance interests and interested departments of dominion and provincial governments.

During their preparation reference was made to analogous publications of the British Standards Institution, standardizing bodies of other British nations, the American Society for Testing Materials, the American Standards Association, the National Electrical Manufacturers Association, the Underwriters' Laboratories Inc., etc.

Sectional Committee on Welding

The organization of a new sectional committee has been authorized under designation "W", to assume the responsibility for the setting up of standards on welding. Existing welding organizations will be transferred to the new section, and additional working committees and subcommittees will be organized to investigate welding standardization in a broader field than hitherto comprehended by the CESA.

Report of Committee 18—Electricity

H. F. Brown, *Chairman,*
D. J. Brumley
D. M. Burckett
F. W. Gardiner
Paul Lebenbaum
W. L. Morse
R. J. Needham
S. R. Negley
A. E. Owen
H. W. Pinkerton
D. B. Thompson, *Vice-Chairman,*
W. M. Vandersluis
R. P. Winton
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Developments in the application of electricity to railway service.
   Progress report submitted as information below.

2. Principal current activities of the Electrical Section, Engineering Division, AAR.
   Progress report submitted as information ..... page 38

Report on Assignment 1

Developments in the Application of Electricity to Railway Service

The past year has been one of increased activity along previously developed lines, rather than one featuring new developments in the application of electricity to the various branches of railway service.

Since the principal efforts of all industry during the past year have been directed toward national defense, the increased burden on the railroads has prevented very much activity, except the intensified use of existing equipment. Two large eastern railroads with extensive electrification, have ordered additional electric motive power—in one case of a type already developed and in service, and in the other of a somewhat new design having greater weight and increased tractive effort. These are not yet in service.

Research in the electrical field still continues, but the introduction of new methods and new apparatus is necessarily retarded by the need for increased production along existing lines. Improvements have been made in circuit breaker design, electrical welders, electrically operated roadway maintenance tools, and in lighting units. Possibly the greatest improvement has been in the fluorescent lighting field, and this type of lamp is being more extensively applied to the various types of interior lighting.

Additional installments have been made of sodium lamps at grade crossings, and some experimental use of Neon tubes has been made for the marking of grade crossing gates.

The use of electric power throughout the country has risen to new record peaks, and there is no doubt that the use of electricity by the railroads, for power, lighting and traction purposes, has risen proportionately with the other industrial uses.

Report on Assignment 2

Principal Current Activities of the Electrical Section, Engineering Division, AAR

The various reports of the committees of the Electrical Section, Engineering Division, have been published and are, therefore, only summarized briefly in this report.

The report of Committee 1—Power Supply—contains a proposed form of agreement for the purchase of electric energy for other than traction purposes. This has been prepared in collaboration with Committee 20—Uniform General Contract Forms. It also includes a report on electric power supply for air conditioning and battery charging service, and presents a proposed specification for the proper phasing of 220-volt, 60-cycle, 3-phase wayside receptacles for use with air conditioning facilities.

The Committee on Overhead Transmission Line and Catenary Construction reports briefly on the status of the revision of the National Electrical Safety Code, which has now been completed, and offers brief comments on the lubrication of overhead contact systems and pantograph shoes.

The Committee on Standardization of Apparatus and Materials submits revised specifications for friction tape for railroad use, specifications for rubber insulating tape, specifications for heat-resisting rubber-insulated wires and cables No. 14 AWG and larger, and submits a report on the principal changes in the existing American Standards since 1938, and also lists specifications of the Signal Section and Telegraph & Telephone Section of the AAR, which are of interest to the Electrical Section.

The Committee on Electric Heating and Welding, collaborating with Committee 27—Maintenance of Way Work Equipment, reports on the advantages and disadvantages of a.c. 60-cycle and 180-cycle d.c. rectifiers, motor generators and other equipment and methods of control used in welding; also, in collaboration with the Medical and Surgical Section, Operating–Transportation Division, AAR, submits a report on health hazards in welding work, which covers electric shocks and burns and the effect of radiant energy, with protective measures for all these hazards.

The Committee on Application of Motors, which functions jointly with the Committee on Motors and Control of the Electrical Section, Mechanical Division, reports on the lubrication of motors and the inspection and maintenance of electrical equipment, and also submits a report on repair shop practice and on the characteristics of the various types of motors, including squirrel cage and wound rotor induction motors, synchronous motors, single-phase motors, special a.c. motors, d.c. shunt wound, series wound and compound wound motors. A very comprehensive report is also included in this report on the design of motor feeders and circuits which gives all the necessary factors for the efficient design and layout of such circuits in suitable form for inclusion in the Manual.

The Committee on Clearances for Third Rail and Overhead Working Conductors has completed its assignment of a diagram of clearance lines for pantograph, catenary construction and adjacent permanent way structures, which has been approved for inclusion in the Manual.

The Committee on Track and Third-Rail Bonds has submitted a report on a study of bond design, with proposed specifications for welded type rail head bonds and track connections for carrying return propulsion current.

The Committee on Illumination has prepared a very comprehensive report on the developments in electric lighting of interest to the railroads, and stresses the advances and improvements made in the development of the fluorescent lamps. This report should be of special interest and value to all railroad electrical men. This committee also submits a brief report on adequate lighting around the outside of shops and power houses, or other locations where much smoke and steam are encountered.

The Committee on High Tension Cables submits a brief report on the installation of oilostatic high tension cables by the Public Service Electric and Gas Company, and on the installation by the Detroit Edison Company of an experimental 120 kv. gas pressure cable for loads up to 95,000 kv.a. Both of these installations represent an advance in the art of electric transmission by high tension cables.

The Committee on the Application of Corrosion Resisting Materials to Railroad Electrical Construction reports briefly on the studies of the tests which are still under way at Lambert Point on the Norfolk & Western, and expects to conclude this report in 1942.

In general, the various committees have submitted comprehensive progress reports, but have not covered all of the assignments because of the increased pressure during the year for routine work, which has limited to a great extent the activities of the members of the section during the past twelve months. In every case full advantage has been taken of the means of collaboration with other various committees and sections of the AAR, as prescribed by the coordinating committee two years ago.

The Committee on Electricity,

H. F. Brown, *Chairman.*

Report of Committee 10—Signals and Interlocking

H. G. Morgan, *Chairman,*
F. H. Bagley*
G. H. Dryden
C. M. Duffy
W. J. Eck
W. H. Elliott
P. M. Gault**
W. N. Hartman
C. R. Hodgdon
J. C. Mock
R. D. Moore
F. W. Pfleging
W. M. Post
A. H. Rudd
J. E. Saunders
H. L. Stanton
H. H. Orr, *Vice-Chairman,*
E. G. Stradling
G. K. Thomas
C. H. Tillett
W. M. Vandersluis
F. B. Wiegand

Committee

* Died August 29, 1941, ** Died September 16, 1941.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Developments in railway signaling.

   Progress report presented as information below.

2. The principal current activities of the Signal Section, AAR, by synopsis, supplemented with list and reference, by number, of adopted specifications, designs and principles of practice.

   Progress report presented as information ..... page 43

The Committee on Signals and Interlocking,
H. G. Morgan, *Chairman.*

Report on Assignment 1

Developments in Railway Signaling

W. M. Post (chairman, subcommittee), G. H. Dryden, W. J. Eck, J. C. Mock, C. H. Tillett.

C.T.C. and Telephones on the Same Pair of Line Wires

Means have been developed and are now available for handling C.T.C. and telephone communication over a single pair of wires at the same time. The arrangement permits the use of standard telephone selectors for telephone calling. Carrier telephone or telegraph circuits may be superimposed on the same pair of wires which serve for C.T.C. and telephone circuits.

No delay or disturbance to either type of service is introduced by this common use of a single pair of wires, except that when telephone selectors are used C.T.C. codes are delayed for the very short time that a selector code is actually in process.

It is very important that a C.T.C. line be strong and well constructed so as to avoid interruption or delay in train service by failure of the line. If a telephone line is already installed or is to be installed, that meets this requirement, the C.T.C. may be handled over that line. If the railroad considers that the telephone line is not substantial enough, a new and better line may be put up for the C.T.C. and the telephone facilities may then be provided on that line.

There are now several installations in service where C.T.C. and other communication service are handled over the same pair of line wires. The telephone communication has been found to be of great value at the time of placing the C.T.C. and associated signaling system in service.

Yard Communication System

A recent development is the introduction of a yard communication system for voice communication between yard offices and switch engine crews in a yard or switching area. It provides for instant transmission of messages to and from switch engines, whether standing or in motion, wherever they may be in the equipped area. It is a carrier current telephone system in which both the sending and receiving apparatus is immediately coupled to the rails, and in which the rails, together with auxiliary lines, serve to carry the communication current between the office and the engines. It may be applied either to a hump yard, a flat yard, or a yard area in which the work of switching crews is controlled from one or more offices.

The communication may be either one-way or two-way, as desired. The one-way equipment is portable and may be quickly transferred from one engine to another. The one-way equipment can be readily changed to two-way equipment when desired.

The system has the character of a simplex communication system in that it is not possible to break in on a conversation. Permits or licenses are not required for the installation nor for operators or maintainers. The use of the yard communication system expedites classification and switching operations and was in regular service in three yards in May 1941.

A New Feature of Coded Track Circuit Control, "The Reverse Code"

The coded track circuit was first developed to not only detect the presence of a train in a block, but also to control the signal at the entrance to that block. To accomplish this, the coded energy is always fed to the exit or leaving end of the block and is detected at the entering end of the block by a code-following track relay. Only the "On" period of the code is used for this purpose.

The "Reverse Code" has recently been developed to utilize the "Off" period of the code. During this "Off" period of the code cycle, track circuit energy is fed at the entrance end of the circuit and is detected by a code-following relay at the exit end of the circuit.

The coded energy which controls the entering signal is called the "Normal Code" and the coded energy which flows in the opposite direction through the track circuit to provide a control at that point is called the "Reverse Code". This "Reverse Code" may be used to control approach lighting, approach energization of cab signal energy, approach locking at interlockings, etc., without the use of line wires.

The coded reverse circuit is now in service on approximately 250 miles of coded track circuits.

Report on Assignment 2

The Principal Current Activities of the Signal Section, AAR By Synopsis

Supplemented With List and References by Number of Specifications, Designs and Principles of Signaling Practice Approved at 1941 Annual Meeting for Submission to Letter Ballot

W. M. Post (chairman, subcommittee), G. H. Dryden, W. J. Eck, W. N. Hartman, J. C. Mock, C. H. Tillett.

Current Activities of the Signal Section, AAR, Since November 1940

In the series of 24 pamphlets on American Railway Signaling Principles and Practices prepared for the education of signal men and others desiring to study this subject, 23 chapters have been completed to date.

The work performed during the 1940 fiscal year and reported at the 1941 Annual Meeting covers the following subjects:

1. Costs involved in stopping trains.
2. Economics of coded track circuit control.
3. Automatic highway crossing gates on the Chicago, Milwaukee, St. Paul & Pacific—economic results.
4. Freight train time saving where trains are operated by signal indication.
5. Freight train time saving where trains are operated by automatic block signals.
6. Economic value of use of reflector units.
7. Economics of revision of automatic block signal spacing incident to greater braking distance.
8. Economics of replacing semaphore signals with light signals.
9. Train hour value.
10. Switch, frog and crossing plans—collaborating with AREA Committee 5.
11. Hearings before the Interstate Commerce Commission under the Signal Inspection Act.
12. Interstate Commerce Commission Order covering manual block signal systems.
13. Automatic train control and automatic cab signals in the United States as of January 1, 1941.
14. Possibility of improper signal operation resulting from the use of rail fissure detector cars and recommended protective measures.
15. Protection against lightning.
16. Methods and circuits for safely and economically providing many signal controls over one pair of wires.
17. Development of proposed inductive coordination measures involving railroad power lines and power equipment—cooperative report.
18. Instructions for electric locking.
19. Simplification and standardization of incandescent electric lamps for railroad signal purposes.
20. Pipe flanges and fittings—cooperative report.
21. Standardization of wire and sheet metal gages—cooperative report.
22. Letter symbols and abbreviations—cooperative report.

23. Tables showing capacity available in various types of primary batteries at solution temperatures ranging from zero degree to 100 deg. F.

24. Table showing capacity available in nickel, iron, alkaline storage batteries at solution temperatures ranging from zero degree to 100 deg. F.

25. Sealing compounds for caulking openings or cracks in housings, such as relay boxes, etc.

26. Electrical insulating materials in general—cooperative report.

27. Federal, state and dominion activities—highway grade crossing protection.

28. Question of interconnecting highway grade crossing signals where two or more parallel railroads are involved and the distance between the railroads which would necessitate more than one pair of signals.

29. Operation of highway crossing protective devices at crossings where a train stops on the operating circuit and does not approach the crossing in a single continuous move.

30. Corrective measures to minimize or eliminate phantom indications on flashing light signals, outlining conditions under which they occur and the corresponding remedy in each case, including the possible use of non-reflector type flasher lamp units.

31. Noteworthy changes in signal practices.

32. Requisites for signal protection for spring switches.

33. Practicability of a flashing light aspect for railway signaling.

34. Modifications of the National Electrical Safety Code to avoid confliction with recognized signal practice.

35. Possible substitution of fire-resisting materials for replacing braid covering for rubber-insulated wires and cables.

36. Possibility of the use of synthetic materials as a substitute for braid coverings of wires and cables.

Revised Specifications Submitted to Letter Ballot

	Old No.	*New No.*
Transformer Oil	46–39	46–41
Rubber Insulating Tape	56–39	56–41
Automatic Block Signal System	63–36	63–41
Electro-Mechanical and Mechanical Interlocking	66–37	66–41
Insulating Compound for Use in Impedance Bonds	7719	77–41
Electric Motor Semaphore Signal	79–39	79–41
Friction Tape for Railroad Use	8226	82–41
Electric Locks	99–39	99–41
Centralized Traffic Control	149–37	149–41
Railroad Highway Grade Crossing Signs	155–40	155–41
Tractive Armature Direct Current Polarized Relay	165–40	165–41
Copper-Covered Steel Wire With or Without Weather-Resistant Covering	167–40	167–41
Highway Grade Crossing Signals	176–37	176–41
Bolts, Nuts and Threads	none	none
Pipe Thread	none	none

Revised Drawings Submitted to Letter Ballot

Solid Jaws with Tang Ends	1018B	1018
Multiple Unit Terminal Block	1054C	1054B
Terminal Blocks	1056E	1056C
Binding Posts	1070F	1070E
Transverse Strap Pipe Carrier—Double Roller Type	1075C	1075B

	Old No.	New No.
Pipe Line Insulation for One-Inch Pipe	1094D	1094C
Suspension Base for Five-Inch Mast	1193B	1193A
Operating Connection for Mechanical Signals	1195B	1195
Concrete Battery Box—Assemblies	1266C	1266B
Concrete Battery Box—Details	1267C	1267B
Concrete Battery Box—Details	1268C	1268B
Crank Bearings and Clamps (for two-way single-lamp signal)	1355B	1355
Double Spectacle Bearing and Lamp Bracket (for two-way single-lamp signal)	1356B	1356
Ladders for Two-Way Single-Lamp Signal	1357C	1357
Tang End with Screw Jaw	1360B	1360
Ladder Parts (Details)	1362C	1362B
Ladder Handrails (Details and Assembly)	1363B	1363
Ladder Platforms (Details and Assembly)	1364C	1364B
Ladders for Ground Mast Signals (Assembly)	1365C	1365B
Ladders for Bridge Masts	1366C	1366B
Ladder Clamps and Stays (Details and Assembly)	1371C	1371B
Electric Lamp Case for Semaphore Lighting	1446B	1446A

Revised Requisites Submitted to Letter Ballot

Protection of Traffic Against Slides and Rock Falls. (Former title Requisites for Fence for the Protection of Traffic Against Slides and Rock Falls.)
Minimizing the Effect of Lightning on Track Circuits.

Revised Instructions Submitted to Letter Ballot

Time Releases Applied to Signal Apparatus. (Former title Instructions for Setting of Time Releases Applied to Signal Apparatus.)
Automatic Interlocking. (Former title Instructions for Inspecting and Testing Automatic Interlocking.)

Revised Miscellaneous Matter Submitted to Letter Ballot

Definitions for Technical Terms Used in Signaling.

New Specification Submitted to Letter Ballot

	No.
Time Element Relay	197–41

New Drawings Submitted to Letter Ballot

Terminal Connectors	1076A
Lag Screw Spike	1381A
Bonding of Oil Sidings—Steam Railroad Territory	1431A
Falling Rock Detector	1505A
Rock Slide Detector	1506A
Earth Slide Detector	1507A
Incandescent Electric Lamps, Bulb Typicals	1541A
Incandescent Electric Lamps, Bases	1542A
Incandescent Electric Lamps, Filaments	1543A

New Instructions Submitted to Letter Ballot

Automatic Highway Grade Crossing Protective Systems.

Drawings Submitted to Letter Ballot for Removal From the Manual

Branch Connection to Line Wire, Double Cross-Arm Support	1403
Branch Connection to Line Wire, Single Cross-Arm Support	1404
Weatherproof Insulated Iron Line Wire Joint	1405
Insulated Wire Joint	1406B
Weatherproof Copper Line Wire Sleeve Type Joint	1407

	No.
Stranded Wire Joint	1408
Branch Connection to Dead Ended Line Wires, Double Cross-Arm Support	1411
Incandescent Electric Lamps and Adapter	1544B
Electric Lamp Case	1563B
Electric Lamp Case	1564B

Miscellaneous Matter Submitted to Letter Ballot For Removal From the Manual

Application of Signals and Cab Signal Aspects and Indications.
Overlaps in Connection with Automatic Signal Systems.
Signal Layout for Remote Switches.

Report of Committee 25—Waterways and Harbors

G. P. Palmer, *Chairman,*
D. J. Brumley
A. C. Clarke
Benjamin Elkind
W. D. Faucette
R. P. Forsberg
I. W. Geer
G. F. Hand
H. F. King
R. W. Marye
R. J. Middleton
F. E. Morrow
W. G. Nusz
A. S. Richardson
E. H. Roth
P. T. Simons
N. D. Hyde, *Vice-Chairman,*
G. R. Smiley*
C. U. Smith
W. R. Swatosh
E. F. Wendt
S. L. Wonson
Committee

* Died June 10, 1941.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   No report.
2. Recommend practices to prevent damage by navigation to;
   (a) Bridges—movable and stationary;
   (b) Piers, wharves and docks.
   No report.
3. Study of metal and other protective casings for pier structures under water.
   No report.
4. Economic principles involved in clearance over navigable waterways.
   No report.
5. Reasonable life of steel casings immersed in sea water.
   No report.
6. Lands subject to servitude of navigation as affecting protection of roadbeds built or to be built on proposed dam pool areas.
   Final report, submitted for adoption below.

The Committee on Waterways and Harbors,
G. P. Palmer, *Chairman.*

Report on Assignment 6

Lands Subject to Servitude of Navigation as Affecting Protection of Roadbeds Built or to be Built on Proposed Dam Pool Areas

R. J. Middleton (chairman, subcommittee), A. C. Clarke, I. W. Geer, F. E. Morrow, W. G. Nusz, P. T. Simons, E. F. Wendt.

Your committee presents this final report and recommends its adoption for publication in the Manual.

"Ordinary High Water Mark" as used herein means the ordinary high water mark under natural river conditions, i.e., prior to construction of the dam, and is determined by field investigation.

Recent court decisions indicate that:

(1) If roadbed is built on lands lying above ordinary high water mark, and water is impounded at elevations above ordinary high water mark, then compensation is due the railroad for any damage to said roadbed.

On the Upper Mississippi River canalization project, involving damages to the Burlington Railroad roadbed lying on the east bank of the Mississippi River near Alma, Wis., the Circuit Court of Appeals, Seventh Circuit, in a decision delivered April 12, 1937 in the case of U. S. v. C. B. & Q. R. R. Co. (90 F (2d) 161) ruled: "The line of ordinary high water divides the upland from the river bed. The river bed is the land upon which the action of the water has been so constant as to destroy vegetation. It does not extend to nor include the soil upon which grasses, shrubs and trees grow. Beyond that point the government cannot go without compensation for proximate damages." Proximate damages are those which accrue directly and in natural sequence, and as specific result of act done, without intervention of independent cause. In another decision, concerning damages to Milwaukee Railroad embankments and structures resulting from the Upper Mississippi River canalization project, the United States Supreme Court on March 31, 1941, in the case of U. S. v. C. M. St. P. & P. R. R. Co., No. 535 (85 L. Ed. 713) ruled that said case be returned to trial court for determination of fact as to whether said embankments are above ordinary high water mark, thereby clearly indicating that railroad is entitled to recover damages to its property so located. Thus, in cases in which protection of roadbeds located on fast land (i.e., not in the stream bed) is required to prevent damages specifically resulting from impounding of water at elevations above ordinary high water mark, cost of said protection may be rightfully recovered from agency responsible therefor.

(2) If roadbed is built on lands lying below ordinary high water mark, then it is considered as lying in the bed of the stream, and no claims for damage can be supported even though water be impounded at elevations above ordinary high water mark.

The aforementioned Supreme Court decision held: "The power of Congress extends not only to keeping clear the channels of interstate navigation by the prohibition or removal of actual obstructions located by the riparian owner, or others, but comprehends as well the power to improve and enlarge their navigability. . . . It is not true . . . that only structures in the bed of a navigable stream which obstruct or adversely affect navigation may be injured or destroyed without compensation by a federal improvement of navigable capacity. On the contrary, any structure is placed in the bed of a stream at the risk that it may be so injured or destroyed; and the right to compensation does not depend on the absence of physical interference with navigation." It follows from the rule laid down by this decision that if roadbed is built on lands lying below ordinary high water mark, compensation is not due the railroad even though embankment sustains injury due to impounding of water at elevations above ordinary high water mark.

(3) Irrespective of whether railroad is built on lands above or below ordinary high water mark, no claims for damage to roadbeds can be supported if water be impounded up to but not above ordinary high water mark.

With further reference to U. S. v. C. M. St. P. & P. R. R. Co., Case No. 535 (85 L. Ed. 713), the Supreme Court ruled: "The dominant power of the federal Government, as has been repeatedly held, extends to the entire bed of a stream, which includes the lands below ordinary high water mark. The exercise of the power within these limits is not an invasion of any private property right in such lands for which the United States must make compensation. The damage sustained results not from a taking of the riparian owner's property in the stream bed, but from the lawful exercise of a power to which that property has always been subject."

Report of Committee 16—Economics of Railway Location and Operation

H. M. Stout, *Chairman,*
E. G. Allen
E. Y. Allen
B. T. Anderson
J. A. Anderson
S. E. Armstrong
J. W. Barriger, III
C. H. Blackman
V. T. Boughton
C. W. Breed
J. L. Campbell
A. B. Chapman
S. B. Clement
L. E. Dale
Miss Olive W. Dennis
J. V. Dillabough
J. H. Dyer
H. H. Edgerton
J. A. Erskine
J. M. Farrin
C. H. Fox
G. W. Hand
C. H. R. Howe
Clark Hungerford
W. B. Irwin
E. E. Kimball
E. E. King
A. W. Laird
Fred Lavis
R. S. Marshall
J. B. Mitchell
L. G. Morphy
J. R. Nagel
F. N. Nye
H. B. Orr
J. A. Parant*
H. R. Peterson
J. W. Porter
J. F. Pringle
C. P. Richmond
M. F. Mannion, *Vice-Chairman,*
R. W. Rogers
E. H. Roth
F. A. Russell
H. F. Schryver
B. J. Schwendt
H. M. Shepard
H. A. Shinkle
L. K. Sillcox
H. W. Snyder
C. B. Stanton
J. M. Symes
J. E. Teal
H. M. Tremaine
W. D. Wiggins
H. W. Williams
S. L. Wonson
J. A. Wood
J. S. Worley

Committee

* Died, September 22, 1941.

To the American Railway Engineering Association:

Your committee submits herewith its report on the following subjects:

1. Revision of Manual.

   No report.

2. Methods for obtaining a more intensive use of existing railway facilities.

   No report.

3. Methods or formulas for the solution of special problems relating to more economical and efficient railway operation.

   No report.

4. Effect of volume of traffic on railway operating expenses, collaborating with Committee 22—Economics of Railway Labor.

   No report.

5. Effect of high speed on railway operating expenses.

   No report.

6. Effect of rail lubrication on train operation, collaborating with Committee 5—Track.

   No report.

7. Economics of railway location and operation as affected by railway electrification, collaborating with Electrical Section, Engineering Division, AAR.

   No report.

8. Effects of speeds in excess of 75 miles per hour on the economics of railway location.
   No report.

9. Train resistance of freight trains under various conditions of loading and speed.
   Progress report, submitted as information ..... page 51

10. Development of modern power units and the effects on the economics of railway location and operation.
    Progress report, submitted as information ..... page 71

11. The general course of the cost of railway transportation and operation over the past 100 years, the principal determining elements and the economic significance.
    No report.

12. The advantage derived from stiffness of track in improving economics of train operation.
    No report.

The Committee on Economics of Railway Location and Operation,
H. M. Stout, *Chairman.*

Joseph A. Parant

Joseph A. Parant, assistant to the chief engineer, Boston & Maine Railroad, Boston, Mass., and a member of this committee, died suddenly at Wolfeboro, N. H., on September 22, 1941. He was born in 1888 at Lawrence, Mass., and received his education in the public schools and at the Massachusetts Institute of Technology.

Mr. Parant's railroad service began with the Boston & Maine in June 1903, when he was but 15 years of age, and his entire professional career was with that railroad. Advancing through various positions in the engineering department, on November 1, 1928, he was appointed principal assistant engineer, which position he held until he was appointed assistant to the chief engineer, February 1, 1939.

He became a member of the American Railway Engineering Association in September 1926, and was appointed to membership of Committee 22—Economics of Railway Labor, April 1, 1929, and to membership of Committee 21—Economics of Railway Operation, March 1933, the latter committee becoming a part of Committee 16, in March 1938. He continued as a member of each of these committees until his death, rendering them valuable service throughout his terms of membership. A special contribution to the work of this committee was his able supervision of the tests for the determination of the effect of rail lubrication on train operation, which were carried out during the summer of 1939 on the Denver & Salt Lake Railway. Also, he made an exhaustive study and was actively interested in the problem of transporting oil and its products through pipe lines.

Mr. Parant was a member of the New England Railroad Club and the Boston City Club, and he took a prominent part in all enterprises of civic interest. He leaves a son, Richard D. Parant, a daughter, Jeanne D. Parant of Melrose, Mass., and a sister, Mrs. Arthur La Plante of Lawrence, Mass.

The committee records here its appreciation of his many estimable qualities and its profound regret at his death. His loss will be deeply felt by it and the Association.

The Committee on Economics of Railway
Location and Operation.

Report on Assignment 9

Train Resistance of Freight Trains Under Various Conditions of Loading and Speed

L. K. Sillcox (chairman, subcommittee), J. W. Barriger, III, L. E. Dale, J. V. Dillabough, J. M. Farrin, A. W. Laird, M. F. Mannion, L. G. Morphy, J. W. Porter, J. M. Symes.

Foreword

The report on Assignment 11, Train Resistance of Freight Trains Under Various Conditions of Loading and Speed, published in Bulletin 420,* concluded with a statement of objectives toward which further effort would be directed, " . . . to continue its search for road test data . . . and, if possible, to submit a preferred general method for calculating train resistance . . .". The present progress report outlines the work which has been done toward that end, and is presented as information.

AREA Train Resistance References

AREA Proceedings, Volume 10, 1909 and following, have been reviewed for the purpose of preparing the summary which follows, of all train resistance references which have been reported to the Association. Such data as are applicable to the present investigation have been taken from the Proceedings.

Summary of Train Resistance Data in AREA Proceedings

Volume	*Page*	*Reference*
11–1	647–666	Train and curve resistance
	649	Effect of different curvatures
	685–686	Resistance, passenger and freight
11–2	1315	Train resistance $R = 4.5V$, when $V = 0$ to 10 m.p.h.
	1322	Train resistance $R = 0.3V + 1.5$, when $V = 10$ to 35 m.p.h.
Manual (1911)	435	Train resistance repeated in Manual—1915
12–1	330	Train resistance formula $2.2T + 121.6C$ Speeds 10–35 m.p.h., $R = 0.3V + 1.5$ Moderately loaded freight cars Speeds 0–10 m.p.h., $R = 4.5$ —Locomotive friction not included Wellington $R = 4 + \frac{V^2}{130}$
13	1155	Train resistance—General discussion of train resistance components—Winter ratings
14	599	Dynamometer tests—Application to tonnage rating
	615	Percent rating based upon grade and temperature
Manual (1915)	535	Train resistance—What data to obtain in dynamometer tests
16	107	Friction resistance equation
	114	Friction resistance equation
	279	Rolling resistance of cars over switches and frogs
18	689	Passenger train resistance—Schmidt
20	931	Study of the mechanics of curve resistance
21	304	Comments on the mechanics of curve resistance
	306	Effect of train resistance on amount of fuel consumed

* Proceedings for 1941, Vol. 42, pp. 69–86.

Volume	*Page*	*Reference*
22	569	The resistance of trains—35 to 75 m.p.h.—Schmidt
	570	Freight train resistance—Schmidt
	573	Passenger train resistance—Schmidt
26	476	Line resistance as a measure of fuel consumption
29	969	Freight train curve resistance on a one-deg. curve and a three-deg. curve
31	1524	Kansas City Southern Tests—rail weight
33	65	Method for finding cost of work done in moving trains against rolling, curve, and rise and fall resistances
34	557	Train resistance
38	409	Effect of rail weight—analytical analysis
	84	Davis Formula
41	151	Rail lubrication

Effect of Track Modulus

Following, a factor is derived, applicable to the Davis general equation for train resistance, which indicates the effect of variable wave action arising from different rail weights and different moduli of elasticity of rail support. The method is based upon the analysis which is given, page 419, Vol. 38, of the Proceedings for 1937. Standard conditions are taken to be represented by 112-lb. rail, $I = 65.8$ in.^{4}, and modulus of elasticity of rail support, $u = 2{,}500$. Under these conditions the coefficient of P in the fourth term of the first equation,

$$\frac{0.0114\,K_r}{\sqrt{I\,u}} = 0.0000349$$

Under conditions of more rigid track, the value of the first term above is less, and if more resilient track, greater than 0.0000349. This is offered as a method of determining total train resistance with correction for rail weight. The relative effect of track rigidity within limits normally encountered is very small.

Derivation

To obtain wave action resistance, first apply equation,

$$X_1 = \frac{\pi}{4}\sqrt[4]{\frac{4\,E\,I}{u}} = 0.785\sqrt[4]{\frac{120{,}000{,}000I}{u}} = 81.8\sqrt[4]{\frac{I}{u}}$$

Then $R = \dfrac{0.0114\,K_rP}{\sqrt{I\,u}}$ (Page 419, Vol. 38, Proc. AREA 1937)

Value of R in Davis formula, assuming 112-lb. rail ($I = 65.8$) laid upon support with $u = 2{,}500$

$$X_1 = 0.785\sqrt[4]{\frac{4 \times 30{,}000{,}000 \times 65.8}{2{,}500}}$$

$$= 0.785\sqrt[4]{\frac{7{,}900{,}000{,}000}{2{,}500}}$$

$$= 0.785\sqrt[4]{3{,}160{,}000}$$

$$= 0.785\sqrt{1{,}775}$$

$$= 0.785 \times 42$$

$$= 33$$

for $X_1 = 33$, $K_r = 1.24$

$$\text{and } R = \frac{0.0114 \times 1.24 \times P}{\sqrt{65.8 \times 2{,}500}}$$

$$= \frac{0.01414\ P}{\sqrt{164{,}500}}$$

$$= \frac{0.01414\ P}{405}$$

$$= 0.0000349\ P$$

$$\text{or } 3.49 \times 10^{-5} P$$

To Incorporate in Davis Formula Factor Providing for Variations in Rail Weight and Modulus of Elasticity of Rail Support

$$R = 1.3 + \frac{29}{w} + KV + \frac{CAV^2}{wn} + \frac{0.0114\ K_r P}{\sqrt{I\,u}} - 0.0000349\ P$$

This equation may also be written,

$$R = 1.3 + \frac{29 - 0.035\ w^2}{w} + KV + \frac{CAV^2}{wn} + \frac{0.0114\ K_r P}{\sqrt{I\,u}}$$

R = train resistance—pounds per ton
w = average weight per axle—tons
n = number of axles
K = constant based upon equipment characteristics
C = constant based upon equipment characteristics
V = speed—m.p.h.
A = cross-sectional area—sq. ft.
P = average wheel loading—lb.
I = moment of inertia of rail—in.^{4}
u = modulus of elasticity of rail support—lb. per in. of length per in. depression
K_r = coefficient of rail resistance corresponding to the value of X_1 from the relationship,

$$X_1 = 82 \sqrt[4]{\frac{I}{u}}$$

where X_1 = distance from wheel load to point of zero bending moment in rail.

Note: Based upon the assumption that Davis equation derived from tests conducted on track of u = 2,500, rail weight = 112, I = 65.8

Air Conditioning Load

The influence of air conditioning load is injected in this freight car analysis only for the reason that there appears to be a growing trend toward axle driven air circulation fans in refrigerator cars, and mechanical refrigeration may become a common development at some future time. The effect of adding a generator load, which also may be interpreted as axle drag from any other cause, is derived on the next page.

Temperature Effects

A determined effort has been made to establish a rational method for correcting the Davis train resistance equation for temperature effects. The Pennsylvania Railroad modification as described in P.R.R. Bulletin No. 26 is outlined and a modifying factor is derived. According to the Pennsylvania data, the total resistance is increased by the stated amounts which limits the use of the data to some narrow speed range—for

Davis Formula to Include Air Conditioning Load of 20-kw. Generators—See Railway Age, May 20, 1939, page 877

Difference Between Total Electrical Load and Lighting

Speed	*Pounds*	*Pounds Per Ton*
20	6,250	5.32
30	4,125	3.51
40	3,125	2.66
50	2,625	2.23
60	2,125	1.81
70	1,940	1.65

$$R = \frac{87.5}{V^{.94}}$$

Constant Journal Flange Air Track Modulus Air Cond.

$$R = 1.3 + \frac{29 - 0.035w^2}{w} + KV + \frac{CAV^2}{wn} + \frac{0.0114\,K_rP}{\sqrt{I\,u}} + \frac{87.5}{V^{.94}}$$

Note: Based upon increased train resistance from 4-kw. generators.

For 15-kw. generator — $R = \frac{59.2}{V^{.925}}$

obviously, all factors in the Davis equation are not affected in the same way by atmospheric temperature and the air resistance member will be affected not at all.

Inquiries were addressed to all members of Committee 16, with respect to the practices of the railways represented in the establishment of correction factors, variable with atmospheric temperature, on tonnage rating of freight trains. Data submitted are presented graphically on the accompanying chart.

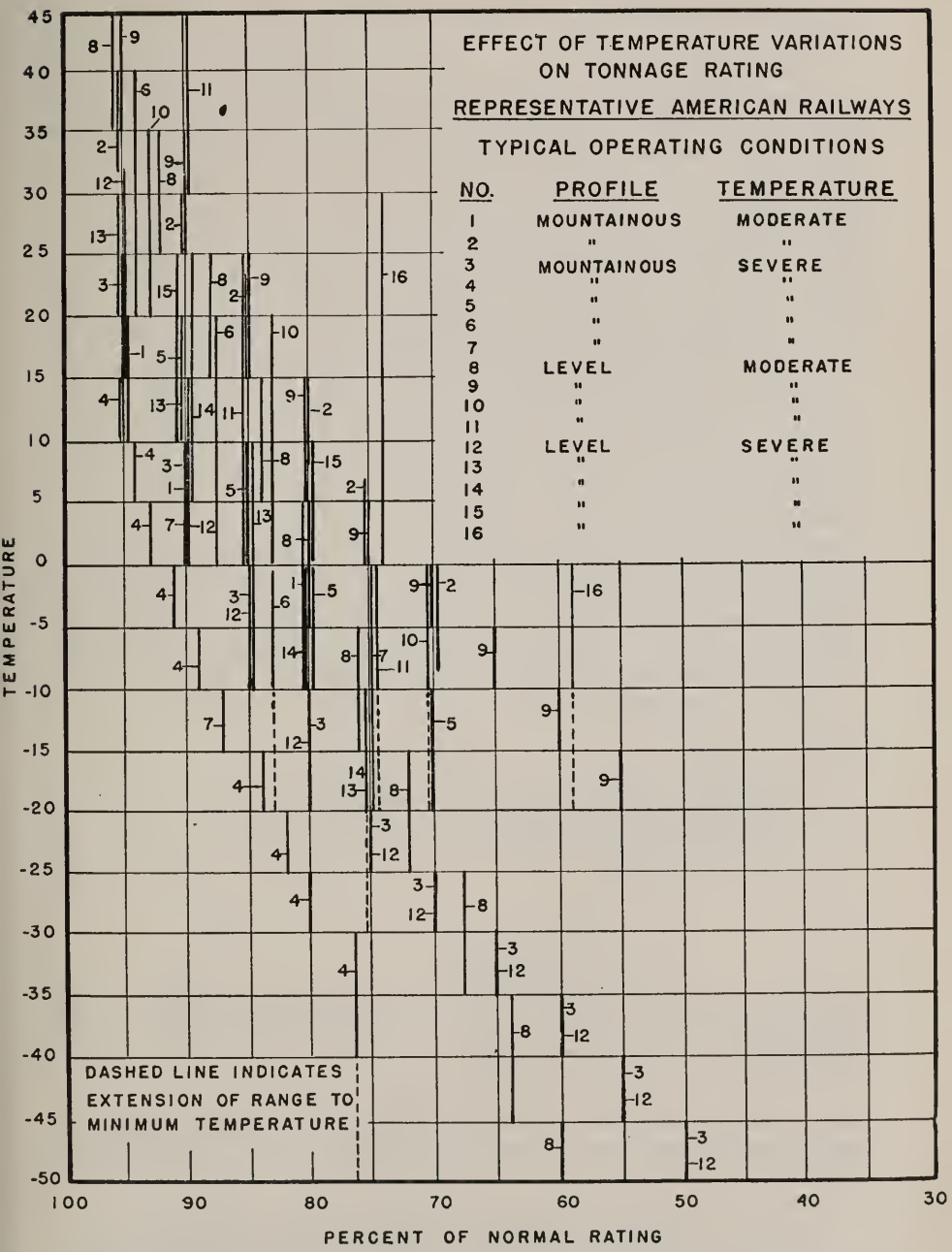
The effect of temperature is not a fixed variable. It is greater on a low grade line with maximum tonnage trains and it may be much greater in regions where low temperatures are generally associated with high winds and drifting snow. However, the chart has been prepared, plotting the temperature ranges within which various percentages of normal tonnage ratings are applied. A relatively narrow band of values may be specified which will embrace practice in nearly all cases. An average curve could be constructed and its equation derived to produce an additional term in the Davis equation but an attempt to fix tonnage ratings in this manner might very well prove embarrassing and there is serious question as to whether or not such a procedure by this committee would be in the best interest of the members of the Association.

Relation Between Temperature and Train Resistance Based Upon Tests as Reported in P.R.R. Bulletin No. 26

Temperature	*Percent of Increase Above Normal*
12	30.00
15	24.50
20	16.50
25	10.75
30	7.75
35	6.00
40	4.75
42.5	4.25

I = Percent increase above normal
T = Temperature

$$I = \frac{2{,}560}{T^{1.705}}$$


EFFECT OF TEMPERATURE VARIATIONS ON TONNAGE RATING
REPRESENTATIVE AMERICAN RAILWAYS
TYPICAL OPERATING CONDITIONS
NO. PROFILE TEMPERATURE
1 MOUNTAINOUS MODERATE
2 " "
3 MOUNTAINOUS SEVERE
4 " "
5 " "
6 " "
7 " "
8 LEVEL MODERATE
9 " "
10 " "
11 " "
12 LEVEL SEVERE
13 " "
14 " "
15 " "
16 " "
DASHED LINE INDICATES EXTENSION OF RANGE TO MINIMUM TEMPERATURE
TEMPERATURE
PERCENT OF NORMAL RATING

Effect Upon Train Resistance of Lateral Forces Due to Side Winds

Synopsis

In the following pages an empirical method of determining the intensity of the lateral forces developed by side winds of varying angularity and velocity is presented. These forces have been, in turn, transformed into unit train resistance values, based upon arbitrarily selected constants. The problem does not lend itself to analytical analysis, hence reliance must be placed upon such test data as are available and, due to practical limitations, possible bases are further confined to laboratory tests as conducted in wind tunnels. Road tests are not feasible due to the large dimensions of railway equipment, the difficulties encountered in controlling the forces of nature in a precise manner, and the obstacles to separating the various components of the total resistance value. Such wind tunnel investigations as have been conducted to date have had, as their primary purpose, the measuring, comparatively, of drag forces as an aid in the selection of the most economical structure contour, beam component measurement being but of secondary interest. The increased wind tunnel sectional areas required when models are revolved from the longitudinal axis of the tunnel has acted as a deterrent to such experiments. The other alternative is a test model of decreased dimensions and, since the evaluation of drag was the primary object, hesitancy to sacrifice model size, with the consequent introduction of increased scale effects, is readily understood. The unfortunate result is, however, a dearth of test data derived from examination of the aerodynamic characteristics of railway equipment and, therefore, in the following analysis, it has been necessary to look to the automotive field for the verification of certain assumptions essential to the method outlined. As will be noted, the United States Bureau of Standards has derived, based upon automotive equipment aerodynamic investigations, a formula relating vehicle speed, wind speed, and the angle obtaining between the two, all expressed in terms of lateral force. Thus,

$$L = C\ a \sin \beta\ K\ A\ V_L^2\ c$$

in which

L = lateral force—lb.
C and K = constants dependent upon vehicle contour
β = angle between locomotive and wind directions—degrees
A = projected frontal area—sq. ft.
V_L = locomotive speed—m.p.h.

$$a = \frac{V_w}{V_L}$$

V_w = wind speed—m.p.h.

$$c = \sqrt{1 + a^2 + 2a \cos \beta}$$

Supporting data, limited in extent, are presented in the analysis which indicate that, for a reciprocating steam locomotive of conventional contour, $C = 8.25$, and the expression may be written,

$$L = 8.25\ a \sin \beta\ K\ A\ V_L^2\ c$$

Further, assuming a locomotive of 120 sq. ft. projected frontal area and employing the value of K as recommended by Davis, 0.0024, the formula may be further simplified to read,

$$L = 2.38\ a \sin \beta\ V_L^2\ c$$

This formula is presented, not as a tool of every day railway operation in assigning tonnage ratings under specified wind and operating speeds, but as information relative to the present state of the art and as a means of measuring lateral forces under various

combinations of speed and angularity to demonstrate the importance of side wind resistance as a part of the whole. Such a comparison, derived from wind tunnel tests, is shown on page 63 of the following analysis.

Introduction

The relationship existing between wind velocity and resulting force has been investigated quite extensively with authorities accepting the expression,

$$P = K\ A\ V^2 \tag{1}$$

as defining the total pressure, P, obtaining when a wind of velocity, V, is directed normally against a flat plate of area, A. No unquestioned value of the constant, K, has as yet been derived but, fortunately, such lack of agreement as is evidenced is of small moment and is not deemed to lead to appreciable error. Generally accepted is the value, 0.003, derived from the famous Eiffel Tower experiments. *C. C. Carter states this constant should be 0.00327 where plates of limited area are involved. Head wind tests on the Berlin–Zozzen Electric Railway in 1903 produced a value of 0.0027. Davis, subsequent to an extensive and painstaking analysis of available data, concluded that, for the standard reciprocating steam locomotive of conventional contour, the coefficient, 0.0024, is most nearly correct. When the rounded contours of electric railway cars and steam locomotives are involved, a reduction of the coefficient is but following the demonstrable law of mechanics that, under similar conditions, the pressure on the convex side of a cylinder is equal to but two-thirds the pressure on the projected area. The Berlin–Zozzen test results and the Davis coefficient are in agreement with this law, both in direction and degree. That is, the steam locomotive head end consists of a greater proportion of curved surfaces than the electric car and, therefore, the coefficient is smaller in value. Carter's limitation relative to plate area is no doubt traceable to experimental results which indicate that total pressure does not vary directly with exposed area. Indications are, however, that variation from the straight-line proportion is of small consequence in practical applications and it is generally ignored.

During 1933 and 1934, a series of tests was conducted in the wind tunnel of the Case School of Applied Science for the New York Central System. The forces produced by a direct head wind upon a standard J–1 Class, Hudson type, locomotive were measured at various wind velocities. Based upon a projected frontal area of 120 sq. ft., the results there obtained indicate a value for K of 0.00161. The several sources, then, of analytical and experimental data are:

K	*Object*	*Source*
0.00327	Flat plate (limited area)	C. C. Carter
0.003	Flat plate	Eiffel Tower experiments
0.0027	Electric railway car	Berlin–Zozzen tests
0.0024	Standard steam locomotive	W. J. Davis
0.0020	Convex side of cylinder	Law of mechanics
0.00161	Standard steam locomotive	Wind tunnel tests—Case School of Applied Science

In the analysis that follows, the Davis coefficient is employed inasmuch as:

1. With the exception of the Case wind tunnel tests, it assumes its logical position in the series of values.
2. It was originally selected after a careful study of results obtained with various locomotive designs and is intended to be general in its scope.
3. Its validity has been demonstrated by practical applications.

* *Simple Aerodynamics*—page 33.

Development of Empirical Formula

R. H. Heald, associate physicist, Bureau of Standards, reports† results of wind tunnel tests wherein the intensity of side winds upon automotive vehicle models was measured at various angles of yaw. He further derives a general expression, based upon these results, with which lateral force can be quickly calculated for various conditions of vehicle speed, wind speed, and relative direction of the two velocities. In the following paragraphs, wind tunnel test data, as obtained by the aforementioned Case School of Applied Science tests, are employed to demonstrate the Bureau of Standards method as applied to the conventional reciprocating steam locomotive.

Let:

V_w = velocity of horizontal wind—m.p.h.
V_L = velocity of locomotive—m.p.h.
β = angle between V_w and V_L—deg.
V_r = resultant velocity—m.p.h.
ϕ = angle of yaw—deg.
L = lateral force—lb.

Then, from trigonometry, resultant wind velocity is expressed by the relationship:

$$V_r = \sqrt{V_L^2 + V_w^2 + 2\, V_L\, V_w \cos \beta} \qquad (2)$$

and

$$\sin \phi = \frac{V_w \sin \beta}{V_r} \qquad (3)$$

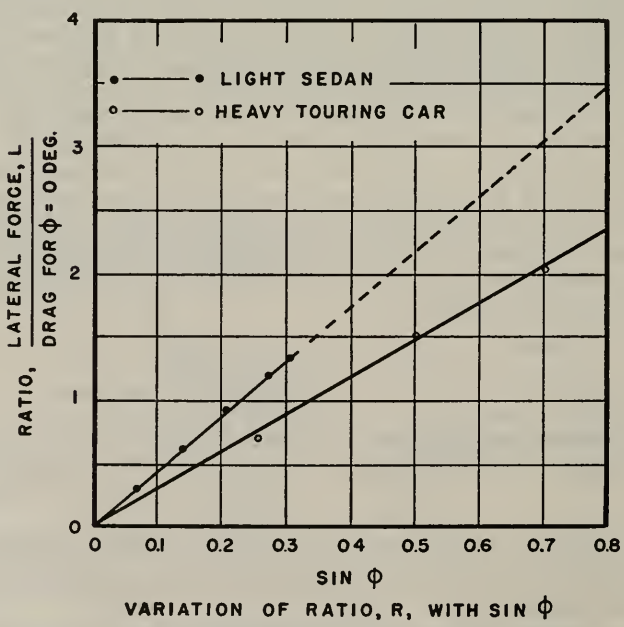


Fig. 1.—Chart Illustrating Consistency of Test Results—Automotive Equipment—U. S. Bureau of Standards.

† Page 18, Vol. 33, No 5, *SAE Journal*

Investigations by the Bureau of Standards have demonstrated that, if the ratio, Lateral Force at a given value of yaw to Drag for zero yaw, is plotted against the sine of the yaw angle, the resulting curve is a straight line which may be expressed algebraically as,

$$R = \frac{\text{Lateral Force}}{\text{Drag for } \phi = 0} = C \sin \phi \qquad (4)$$

where ϕ is the angle of yaw and C is a constant whose value is a function of vehicle characteristics. This relationship is valid only throughout the range, $\phi = 0$ deg. to $\phi = 45$ deg. Due to space limitations of the Case School wind tunnel, the locomotive model could be tested at but 15 deg. yaw and for the application of this method it is necessary to base the value of C in equation (4) upon one point only. This would lead to serious error should results of individual tests vary to any considerable extent. To illustrate the variations obtained in the tests of automotive vehicle models, and indirectly, the probable error to be expected from drawing the curve through but one point,

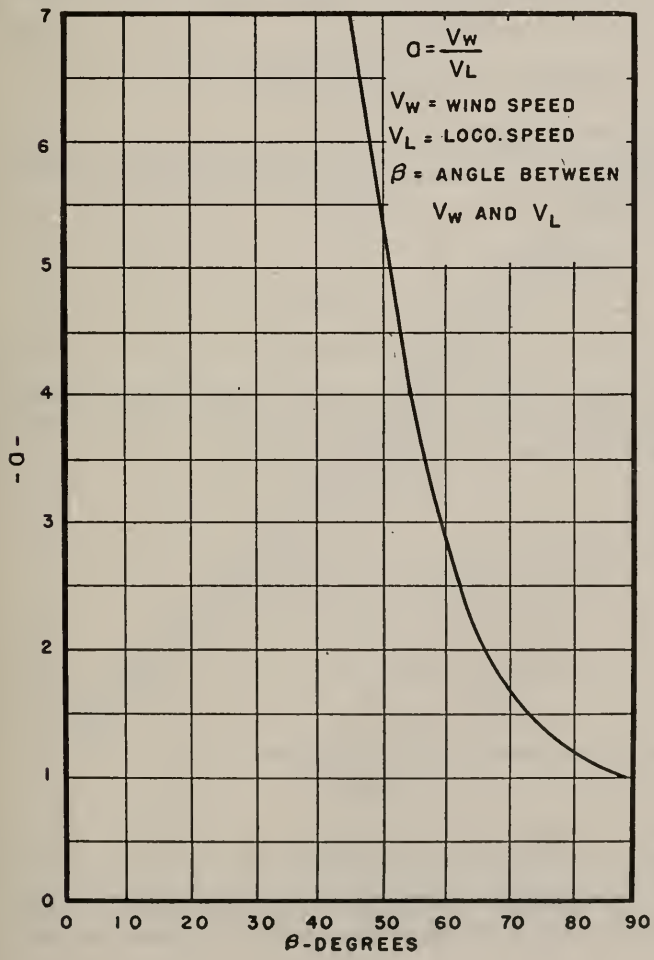


Fig. 2.—Maximum Values of a for Which Method is Applicable, Based upon Minimum Locomotive Speed of 10 m.p.h.

Fig. 1 is included. The consistency of test results obtained at Case is illustrated in the following table:

Relative Velocity—m.p.h.	*Lateral Force* $\phi = 15$ *deg.*	*Drag* $\phi = 0$	R
40	662	309	2.14
50	1,031	482	2.14
60	1,488	694	2.14
70	2,026	945	2.14
80	2,642	1,234	2.14
90	3,340	1,562	2.14
100	4,130	1,930	2.14

Then, from equation (4), for $\phi = 15$ deg.

$$2.14 = C \times 0.259$$
$$C = 8.25$$

and for the general case,

$$R = 8.25 \sin \phi \tag{5}$$

By definition, $R = \dfrac{\text{Lateral Force, } L}{\text{Drag at } \phi = 0 \text{ deg.}}$

Drag, by equation (1), $= K\ A\ V_r^2$

where, V_r, is the resultant wind speed assumed to be directed against the frontal area.

Then $$R = \frac{L}{K\ A\ V_r^2}$$

or, from equation (5),

$$\frac{L}{K\ A\ V_r^2} = 8.25 \sin \phi$$

and $$L = 8.25 \sin \phi\ K\ A\ V_r^2 \tag{6}$$

For convenience in applying the equation to practical problems where locomotive speed, wind speed, and angle obtaining between the two velocities are usually the known factors, it is desirable that equation (6) be stated in those terms.

$$\text{Let } a = \frac{V_w}{V_L} \tag{7}$$

substituting in equation (2),

$$V_r = \sqrt{V_L^2 + a^2\ V_L^2 + 2a\ V_L^2 \cos \beta}$$
$$= V_L \sqrt{1 + a^2 + 2a \cos \beta} \tag{8}$$

If $$c = \sqrt{1 + a^2 + 2a \cos \beta} \tag{9}$$

Then $$V_r = c\ V_L \tag{10}$$

Substituting a and c into equation (3), $\sin \phi$ is expressed as,

$$\sin \phi = \frac{a \sin \beta}{c}$$

and equation (6) becomes

$$L = 8.25\ a \sin \beta\ K\ A\ V_L^2\ c \tag{11}$$

In equation (11), the relationship is expressed in its most general form and leaves to the user's judgment the values of K and A most appropriate for his individual study.

Selecting, however, the Davis coefficient as applicable to a large locomotive of 120 sq. ft. projected frontal area, the equation assumes the form,

$$L = 2.38\ a \sin \beta\ V_L^2\ c \tag{12}$$

which is employed in the preparation of accompanying illustrative curves.

As stated in a foregoing paragraph, this method is invalid for values of ϕ exceeding 45 deg. since the straight-line relationship between R and sin ϕ does not exist at greater angularity. For quick reference, and to avoid unnecessary calculations in the application of the formula, Fig. 2 has been prepared. Obviously, three factors are involved, V_w, V_L, and β, and, inasmuch as the ratio, V_w to V_L, may be expressed as a, values of β may be plotted against that term, in which case the formula does not hold for values of a falling to the right of the curve. It will be noted that limiting values occur only when considerable differences exist between wind and train speed, and then only for large values of β.

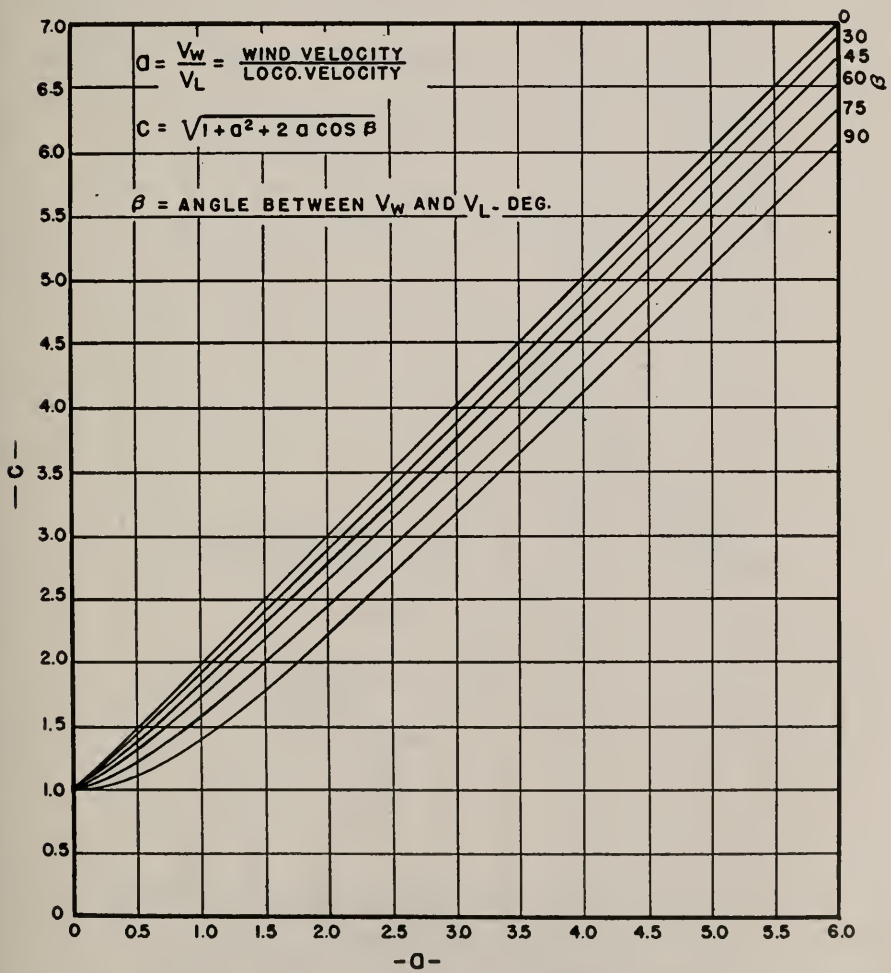


Fig. 3.—Relation Between a and c for Various Values of β. Range $a = 0$ to 6.

Illustrative:

β—Degrees	V_L—M.P.H.	Limiting Max. Values V_w—M.P.H.	a
90	10	10	1.0
90	30	30	1.0
75	10	14	1.4
75	30	42	1.4
60	10	27	2.7
60	30	81	2.7
45	10	70	7.0
30	10	No practical limit	

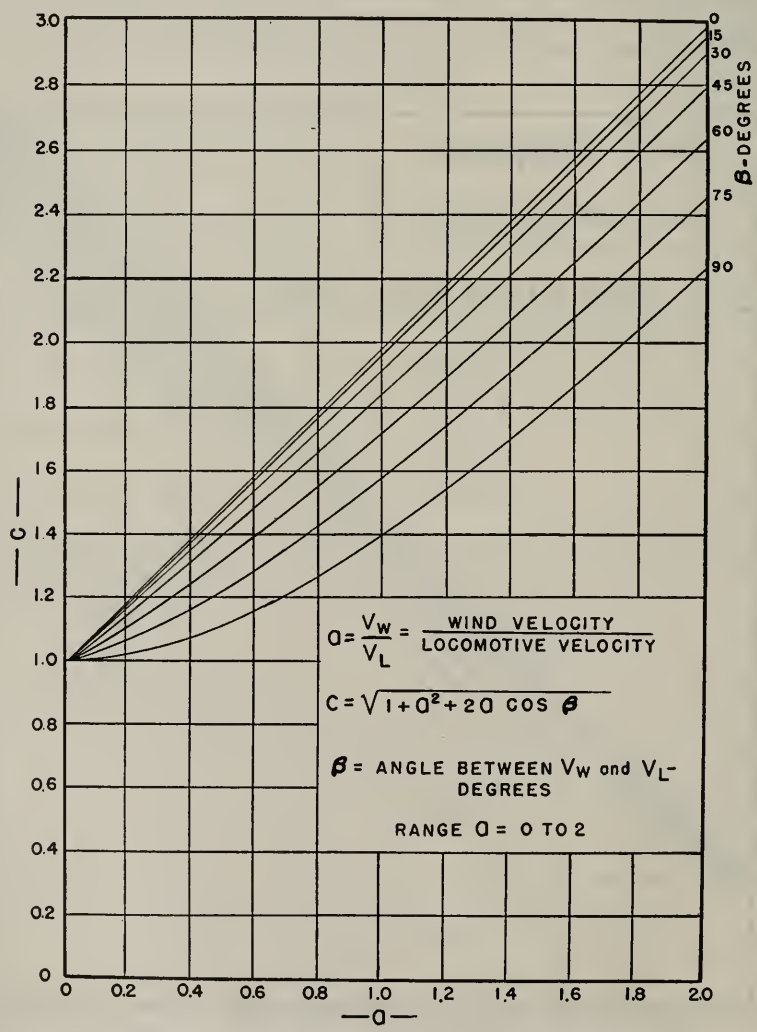


Fig. 4.—Relation Between a and c for Various Values of β.

Fig. 3 is presented to minimize calculations required in the application of equation (12). Values of *a*, by definition, are known immediately when wind and locomotive velocities are determined and values of *c*, the more involved factor, are then read directly. Fig. 3 is deemed sufficiently extensive in scope to include any wind-locomotive velocity combination likely to be met in practice. Inasmuch as the great majority of combinations, however, result in a value of *a* smaller than 2, Fig. 4 is included to reduce scale effects in this important range.

The variation of lateral force with wind speed at a given locomotive speed is illustrated in Fig. 5. For example, assuming a wind speed of 40 m.p.h., a locomotive speed of 60 m.p.h., and an angle of natural wind, β, of 60 deg., the resulting lateral force is

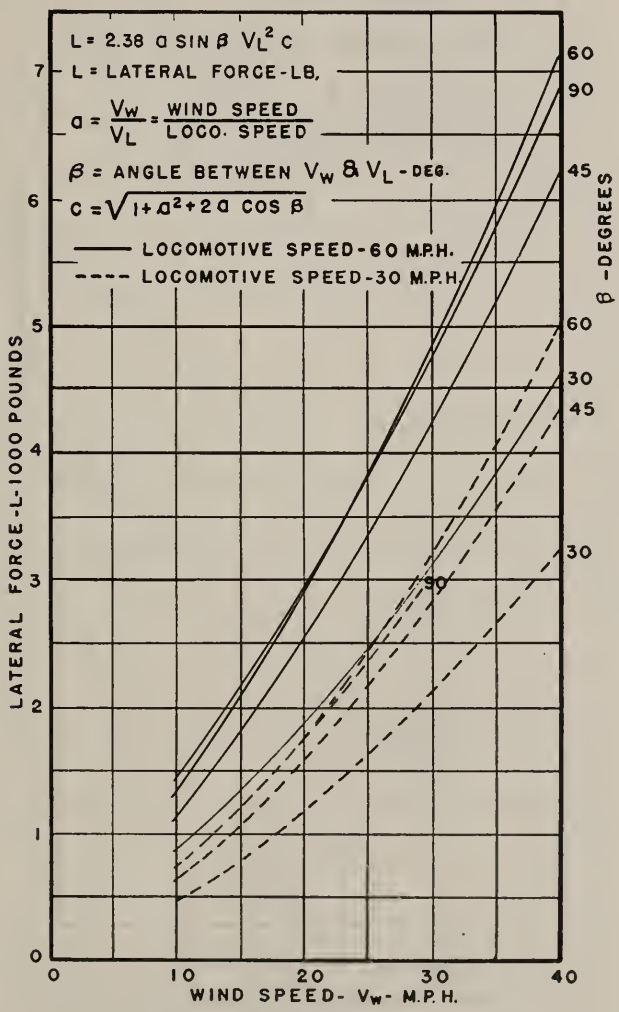


Fig. 5.—Variation of Lateral Force with Wind Speed.

of the order of 3.5 tons. Further assuming a coefficient of friction between rail and wheel of 20 percent, the total resistance would equal 1,400 lb. or, for a 300-ton locomotive, 4.67 lb. per ton of locomotive weight. Of interest, is the effect produced by varying natural wind angle between 60 and 90 deg.

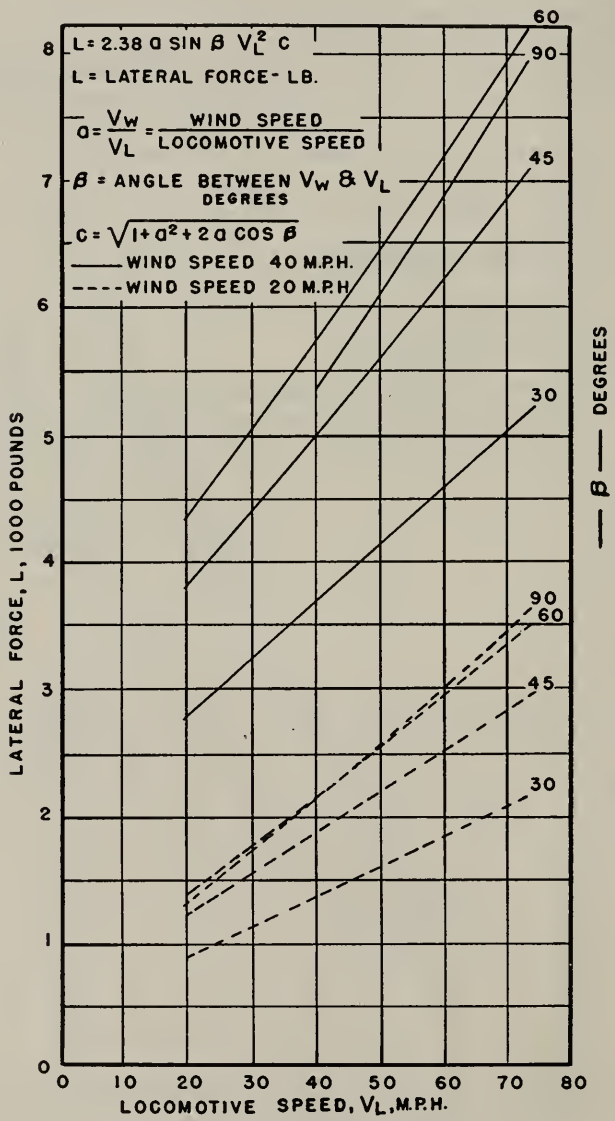


Fig. 6.—Variation of Lateral Force with Locomotive Speed.

β	*Wind Speed*	*Loco. Speed*	*Lateral Force*
60	10	60	1,325
90	10	60	1,425
60	22	60	3,300
90	22	60	3,300
60	40	60	7,150
90	40	60	6,840

That is, with constant locomotive speed, a 60 deg. natural wind produces a greater lateral force than does a direct side wind for wind speeds above 22 m.p.h., approxi-

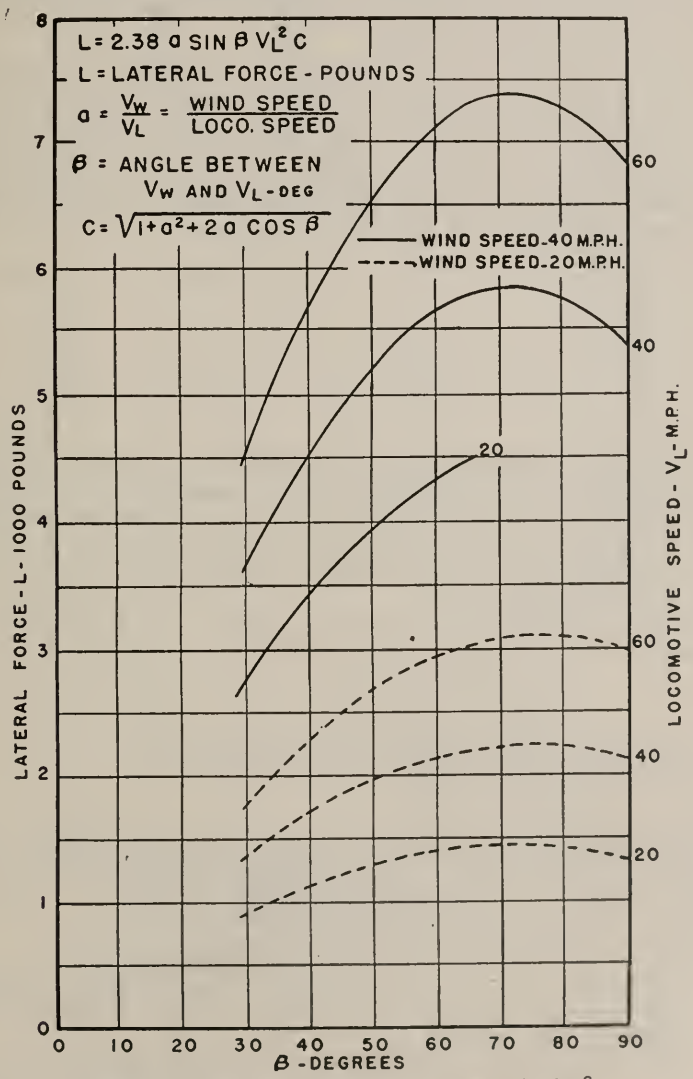


Fig. 7.—Variation of Lateral Force with Angle β.

mately, while, in the wind range below 22 m.p.h., the reverse is true. Examination of equation (12) discloses that this is occasioned by the varying values of sine and cos β.

Fig. 6 illustrates the variation of lateral force with locomotive speed for various values of β. It will be observed that, with greater angularity of natural wind, the effect of varying locomotive speed is more pronounced. Also, a comparison of Figs. 5 and 6 demonstrates that changes in wind speed have a greater effect upon lateral force than do like changes in locomotive speed.

In Fig. 7, lateral force has been plotted against natural wind angle, β, for representative wind-locomotive speed combinations. Maximum lateral forces are indicated in the neighborhood of $\beta = 75$ deg., from which point a gradual reduction occurs. This effect is more evident at higher wind speeds.

A strong side wind, or a wind-locomotive speed combination which produces high lateral forces, presses wheel flanges against rail head, thereby initiating a frictional resistance to forward motion. Assuming this resistance to vary directly with total lateral force, and a coefficient of friction of 20 percent, Fig. 8 has been prepared. Of possible interest, conditions which result in unit resistance of four lb. per ton are tabulated below. It is understood, of course, that these are but representative conditions as illustrated on accompanying curves and that many others may obtain.

β—*Degrees*	V_w—*M.P.H.*	V_L—*M.P.H.*
60	35	60
90	36	60
45	39	60
60	40	44
90	40	49
45	40	57

In Figs. 9 and 10, families of curves have been drawn in order that unit resistance may be read directly for representative wind and locomotive velocity combinations throughout the range, $\beta = 10$ deg. to $\beta = 90$ deg. The angle, Beta, is selected as the abscissa to reduce to a minimum the number of curves required. For most purposes, these sheets eliminate the necessity of applying the formula in the determination of resistance due to side winds.

The nomographic chart, Fig. 11, provides a method for the graphical solution of the equation,

$$R_u = \frac{2.38\ a \sin \beta\ V_L^2\ c\ f}{W} \tag{13}$$

where R_u = unit locomotive side wind resistance—lb. per ton
f = coefficient of rubbing friction between wheel and rail
W = locomotive weight—tons

It will be noted that equation (13) is but a restatement of equation (12), in terms of unit resistance rather than lateral force and all other variables are defined as before. To facilitate comparison between algebraic and graphical results, Fig. 11 is based upon a coefficient of friction of 0.20 and a locomotive weight of 300 tons.

To read the nomographic chart, the following operations are required:

1. Connect given V_w and V_L and note where line cuts left support. The extension of this line (shown broken on the chart) to the a scale enables the direct reading of many values of a.
2. Connect given β and c and note where line cuts right support.

(text continued on page 71)

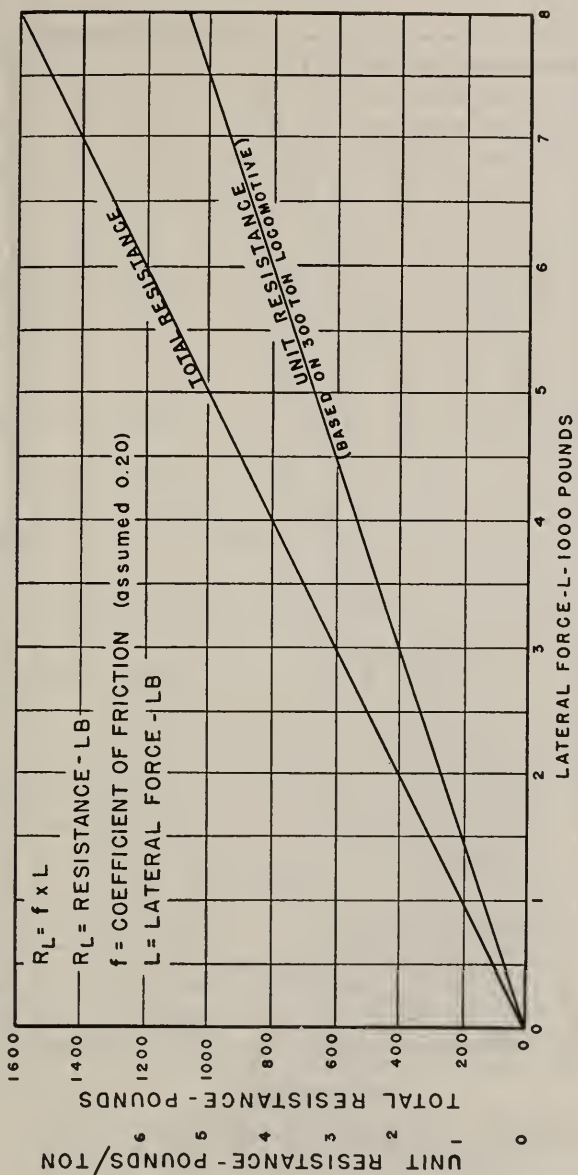


Fig. 8.—Resistance Due to Side Winds.

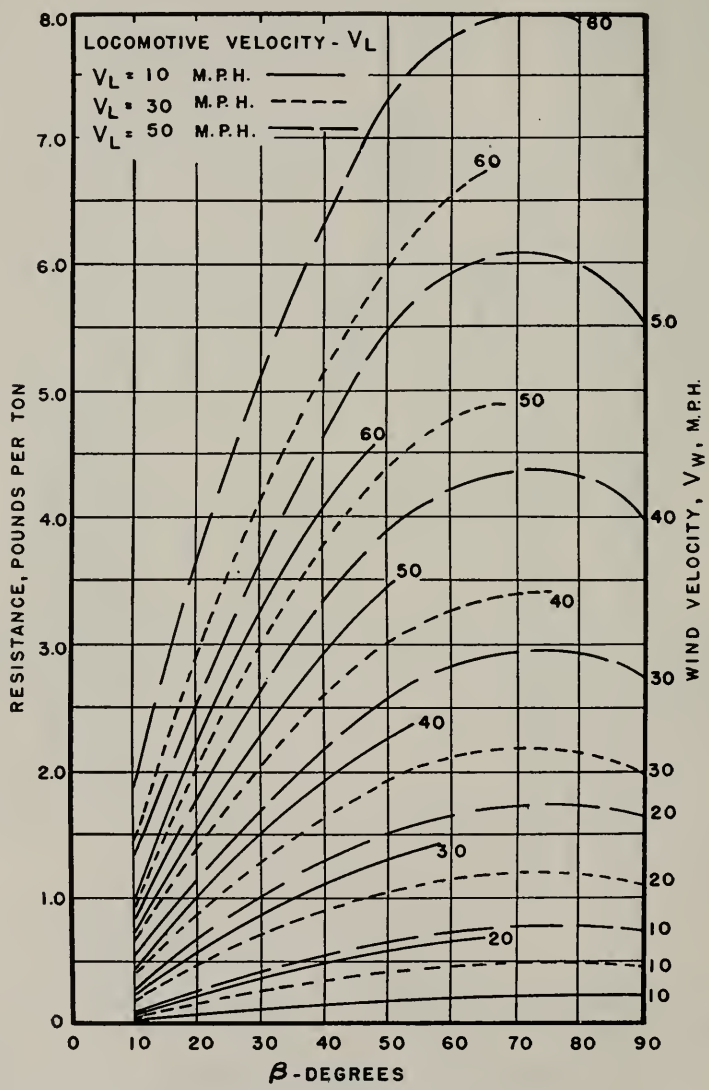


Fig. 9.—Variation of Resistance with Angle β. Based on a 20 Percent Coefficient of Friction and a 300-Ton Locomotive.

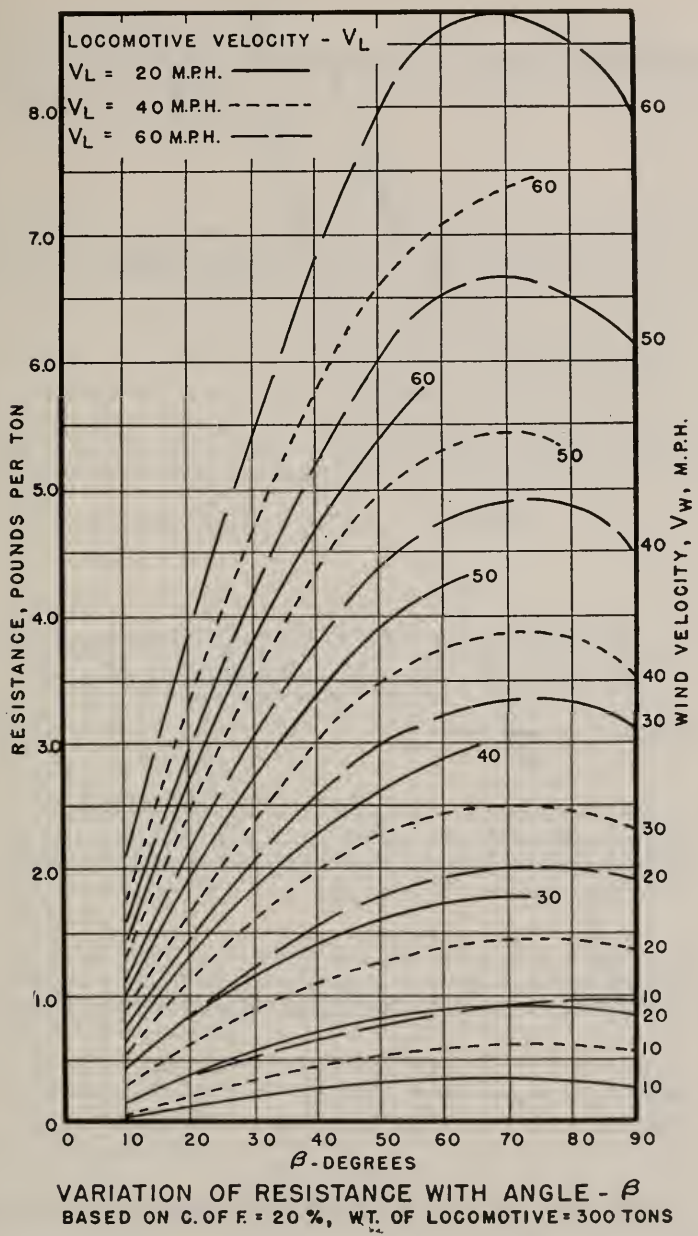


Fig. 10.—Variation of Resistance with Angle β. Based on Coefficient of Friction = 20 Percent, Weight of Locomotive = 300 Tons.

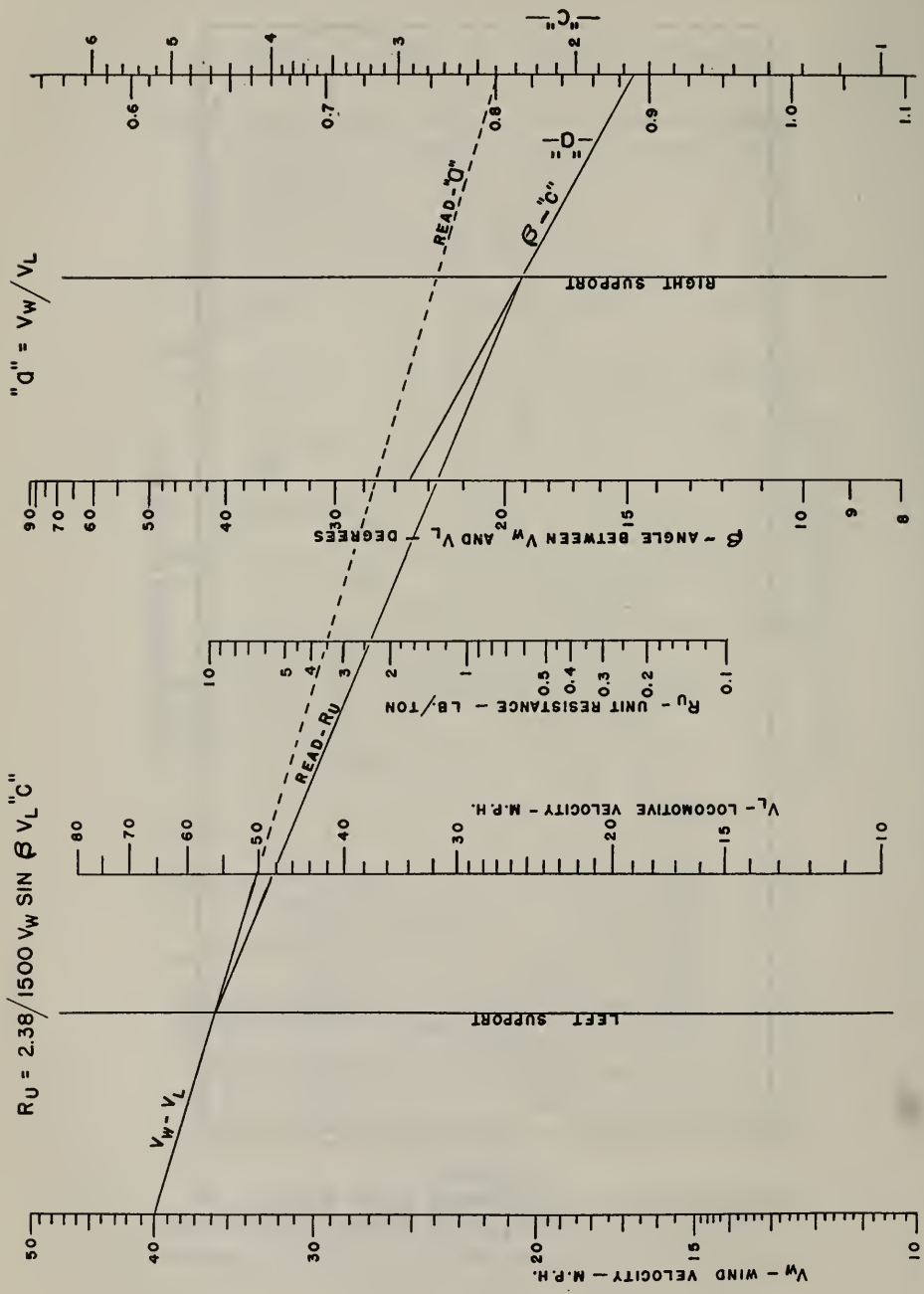


Fig. 11.—Nomographic Chart for the Solution of Equation (13).

(text continued from page 66)

3. Read R_u where the line connecting the two previously determined points on right and left supports cuts R_u scale. Reference to Figs. 3 or 4 is required for the determination of values of c.

Conclusion

Unfortunately, the constant term of the suggested formula does not lend itself to analytical derivation and can only be determined accurately by test. This would involve wind tunnel investigation of the various railway freight equipment types in combinations which could only be determined as the investigation progressed. The preceding analysis is offered as information without recommendation as to its practicability in railway operation. It does, however, indicate the importance of lateral forces and the extent to which they enter into the total resistance value. Realizing the difficulties to be overcome in defining, on a logical basis, exact values of side wind resistance, and the constantly varying wind and locomotive directions as the train advances throughout its assigned run, it does not appear that this resistance component should be ignored when determining train resistance in the aggregate.

Report on Assignment 10

Development of Modern Power Units and the Effects on the Economics of Railway Location and Operation

E. E. Kimball (chairman, subcommittee), J. W. Barriger, III, A. B. Chapman, J. A. Erskine, W. B. Irwin, J. B. Mitchell, H. R. Peterson, C. P. Richmond, L. K. Sillcox, H. W. Snyder, H. W. Williams.

In general American railroads have been built up around the steam locomotive, hence it can be assumed that many of the changes which have taken place in the type and construction of roadway and track structures are due in large measure to the nature of the developments that have been made in the design and construction of steam locomotives.

The committee intends to investigate some of the important trends in steam locomotive construction and study their effects as a matter of interest and, if possible, present examples of actual cases based on comparative studies where projects have been completed and data are available.

Reference will be made to Diesel electric and other types of motive power and also to some of the advances made in the design and construction of new rolling stock.

The committee reports progress in the assembling of data on the subject and in the analysis of the economic effects.

This report is presented as information.

Report of Committee 13—Water Service, Fire Protection and Sanitation

B. W. DeGeer, *Chairman,*
R. C. Bardwell
W. M. Barr
W. E. Bickel
C. W. Brown, Jr.
C. B. Bryant
R. W. Chorley
R. E. Coughlan
W. L. Curtiss
J. H. Davidson
G. E. Durham
P. W. Elmore
F. A. Feikert*
R. N. Foster
J. P. Hanley
C. K. Holden
R. L. Holmes
A. W. Johnson
H. F. King
C. R. Knowles
H. M. Laudemann
J. J. Laudig
O. E. Mace
Ray McBrian
W. A. McGee
H. L. McMullin
G. F. Metzdorf
R. H. Miller
E. R. Morris
Theodore Morris
M. F. Neuzil
A. B. Pierce
E. M. Grime, *Vice-Chairman,*
W. G. Powrie
S. E. Printz
W. A. Radspinner
O. T. Rees
H. M. Schudlich
H. E. Silcox
R. M. Stimmel
J. E. Tiedt
C. P. Van Gundy
H. W. Van Hovenberg
R. E. Wachter
K. J. Weir
J. B. Wesley
Committee

* Died, September 27, 1941.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, including recommended revisions ..... pages 74 and 81

2. Cause of and remedy for pitting and corrosion of locomotive boiler tubes and sheets, with special reference to status of embrittlement investigations.

   Progress report—submitted as information ..... page 82

3. Value of water treatment.

   No report.

4. Progress being made by federal or state authorities on regulations pertaining to railway sanitation, collaborating with Joint Committee on Railway Sanitation, AAR.

   Progress report—submitted as information ..... page 83

5. The principal current activities of the Fire Protection and Insurance Section, AAR.

   Progress report—submitted as information ..... page 84

6. Use of anti-foam compounds to reduce road blowing.

   Progress report—submitted as information ..... page 85

7. Specifications for welded steel tanks for water service, collaborating with Committee 15—Iron and Steel Structures, and the American Welding Society.

   Final report—submitted for adoption ..... page 88

8. Methods for cleaning sewers and underground pipe lines.

   Progress report—submitted as information ..... page 93

9. Practicable size of water columns and supply lines for maximum delivery of water to locomotive tenders.

Progress report—submitted as information ..... page 99

THE COMMITTEE ON WATER SERVICE, FIRE PROTECTION AND SANITATION,
B. W. DEGEER, *Chairman.*

Report on Assignment 1

Revision of Manual

E. M. Grime (chairman, subcommittee), W. M. Barr, C. W. Brown, Jr., C. B. Bryant, R. N. Foster, C. K. Holden, H. F. King, H. L. McMullin, R. H. Miller, E. R. Morris, R. E. Wachter, K. J. Weir.

The heading in the Manual on page 13–27 reads: Specifications for Steel Substructures for Water Tank. Revise this to read: Specifications for Steel Substructures for Wood Water Tanks.

Since the committee is now presenting for inclusion in the Manual, specifications for welded steel tanks, it is proper to change the heading on page 13–37 which now reads: Specifications for Steel Water and Oil Tanks to read: Specifications for Riveted Steel Water and Oil Tanks.

In paragraph 3 on the same page the weight of water is shown as 63 pounds. It is desired to correct this to read 62.5 pounds.

In the same paragraph the Manual now shows wind pressure in pounds assumed to be 30 times the product of the height by ⅔ of the diameter of the tank in feet. To make this conform to commonly accepted practice and also have it agree with the specifications for welded steel tanks it is recommended that this specification for loading be revised to read as follows: Wind pressure acting in any direction, shall be assumed to be 40 pounds per square foot of vertical projection.

In paragraph 8, page 13–38, minimum thickness for flat bottom plates now reads $\frac{5}{16}$ inch. Revise this to read ⅜ inch.

The matter under Standard Methods of Water Analysis and Interpretation of Results, which was adopted ten years ago, should now be rearranged and amplified to make that part of the material appearing on pages 13–60 to 13–64 conform with the refinements now required for accurate boiler feedwater treatment. This revised material is as follows, starting with Field Survey, page 13–60.

Reagents

All chemicals referred to shall be *reagent* grade.

Standard Calcium Chloride Solution.—Dissolve 0.5 grams of pure calcite (calcium carbonate) in a little dilute (1:4) hydrochloric acid, being careful to avoid spattering. Wash down and make slightly alkaline with ammonium hydroxide. Make up to 500 ml. with carbon dioxide free distilled water and store in a glass-stoppered resistant glass bottle. One ml. of this solution is equivalent to 1.0 mg. calcium carbonate.

Standard Soap Solution.—Make up a saturated solution, by shaking vigorously, a sufficient quantity of sodium oleate or powdered castile soap in one liter of 80-percent specially denatured (No. 3A or No. 30) ethyl alcohol and allow to stand at least 12

hours. Decant, and filter if necessary. Dilute the clear liquid with 70-percent alcohol until one ml. is equivalent to one ml. of the standard calcium chloride solution, making due allowance for the lather factor. One ml. of this solution is equivalent to one mg. of calcium carbonate.

N/50 sulphuric acid

N/50 sodium carbonate

N/20 soda reagent.—Prepared by mixing equal volume of solutions of *N/20* sodium carbonate and *N/20* sodium hydroxide. (Note.—The soda reagent used in sanitary water analysis is of *N/10* strength).

Phenolphthalein indicator

Methyl orange indicator

10 percent Barium Chloride Solution.—Dissolve 100 grams barium chloride crystals in one liter of distilled water. Using phenolphthalein as indicator, neutralize acidity with *N/50 NaOH* until faint pink color appears.

Winkler's Solution.—Dissolve 200 grams sodium potassium tartrate and 12 grams sodium hydroxide in distilled water making up to one liter.

Standard Sodium Chloride Solution.—Dissolve 1 gram of fused sodium chloride in 1 liter of distilled water. One ml. is equivalent to 1 mg. *NaCl.*

Standard Silver Nitrate Solution.—Weigh about 2.90 grams of silver nitrate and dissolve in 1 liter of distilled water. Adjust so that 1 ml. of this solution is equivalent to 1 ml. of standard sodium chloride solution. One ml. is equivalent to 1 mg. *NaCl.*

Potassium chromate indicator

Saturated lime water.—Prepared by shaking excess of calcium hydroxide with distilled water, letting settle, and using the clear supernatant liquid.

Saturated sodium tetraborate solution

Saturated oxalic acid solution

N/25 potassium permanganate solution

Molybdate solution.—Dissolve 37.5 grams of ammonium molybdate in 600 ml. of distilled water and add 300 ml. of concentrated sulphuric acid, cool and make up to 1,000 ml.

Sulfite solution.—(1) Dissolve 90 grams of sodium bisulfite in 800 ml. of distilled water. (2) Dissolve 7 grams of sodium sulfite (anhydrous) in approximately 100 ml. of distilled water. To solution (2) add 1.5 grams of 1-amino-2-naphthol-4-sulfonic acid, mix until dissolved, and add to solution (1). Make up total volume to 1,000 ml. with distilled water.

Sodium tungstate-phosphomolybdic acid solution.—One hundred grams of sodium tungstate, 20 grams of phosphomolybdic acid, and 50 ml. of 85 percent phosphoric acid are dissolved in 750 ml. of water. The liquid is boiled under reflux for 2 hours, cooled and made up to 1 liter.

Saturated sodium carbonate.—Add enough sodium carbonate to 1 liter of water to supersaturate the solution with respect to $Na_2CO_3.10H_2O$ and allow excess to crystallize.

RAPID FIELD TESTS

Field tests generally are used to determine calcium and magnesium salts or approximate hardness, alkalinity and chlorides. The following procedure gives satisfactory results for raw, feedwater, or boiler water:

Procedure

Raw Water Tests

(a) *Total Hardness.*—Measure 58.3 ml. (or fractional sample if hardness is greater than 15) of the water to be examined into an eight ounce bottle. If desired add 1 ml. of a saturated sodium tetraborate ($Na_2B_4O_7$) solution. If a fractional sample is used make up to 58.3 ml. with distilled water. Add the standard soap solution in 0.5 ml. amounts shaking vigorously after each addition until a stable lather is secured which will stand up for 5 minutes. As the end-point is approached reduce the additions of soap solution to 0.1 ml. depending upon the accuracy desired and experience of the manipulator. Note and record any false end-point (Ghost Point) which is the dividing line between the calcium and the magnesium salts. Deduct lather factor from maximum false end-point reading to obtain the calcium hardness in grains per gallon as $CaCO_3$. The final burette reading after deducting the lather factor gives the total hardness in grains per gallon as $CaCO_3$. The difference between the total hardness and the false end-point gives the magnesium hardness expressed as calcium carbonate. If a fractional sample is used deduct the lather factor and then multiply the reading by the proper factor.

To avoid mistaking the false end-point for the true one when adding the soap solution to waters containing magnesium salts read the burette after the titration is apparently finished and add about 0.5 ml. more of soap solution. If the end-point was due to calcium the lather will disappear. Soap solution must then be added until the true end-point is reached. Usually the false lather persists for less than 5 minutes.

Note 1. Acid waters should be neutralized with *N/50* sodium carbonate using methyl orange indicator before the addition of sodium tetraborate and proceeding with test.

Note 2. Winkler's method for determination of calcium. If the false end-point is indefinite and careful determination of calcium is necessary take a 58.3 ml. sample and add 2 ml. Winkler's solution. Run test as usual and final end-point gives calcium hardness. The lather formed at the end-point in this case is less stable than in the regular soap test. If the calcium hardness is greater than ten a fractional sample should be used, adding the Winkler's solution before making up to 58.3 ml. with distilled water.

(b) *Alkalinity.*—Titrate 58.3 ml. of the water under investigation with *N/50* sulphuric acid solution, using methyl orange indicator. The number of milliliters of *N/50* sulphuric acid used gives the alkalinity (A) directly as grains per gallon in terms of calcium carbonate.

In case of alkaline waters, if the total hardness is greater than the alkalinity, the difference represents the non-carbonate hardness. If the total hardness is less than the alkalinity, the difference is sodium carbonate, all of the hardness being then in the form of carbonate hardness. In case of acid waters, all of the hardness will be non-carbonate hardness.

(c) *Acidity.*—In case the water under investigation is acid to methyl orange, titrate 58.3 ml. sample with *N/50* sodium carbonate solution, using methyl orange indicator. The acidity is obtained directly as grains per gallon in terms of calcium carbonate.

Treated Water Tests

(a) *Hardness.*—Determination is made in same manner as indicated in (a) for raw water omitting sodium tetraborate.

(b) *Alkalinity.*—Titrate 58.3 ml. of the water with *N/50* sulphuric acid solution, using phenolphthalein indicator. Multiply the reading by 2.0 and record as causticity modulus (C).

Add methyl orange indicator to the colorless solution and continue the titration with *N/50* sulphuric acid solution, recording the final reading (that is, the sum of the phenolphthalein and methyl orange requirements) as alkalinity (A).

The difference between the hardness (H) and the alkalinity (A) shows the presence of soda ash if the alkalinity (A) is in excess, or an absence of soda ash if the hardness (H) is in excess, all directly as grains per gallon in terms of calcium carbonate. Likewise, excess of the causticity modulus (C) over the alkalinity (A) indicates the presence of lime or caustic soda, while an excess of alkalinity (A) over causticity modulus (C) shows an absence, either being reported directly as grains per gallon in terms of calcium carbonate. In other words, this difference shows the amount of the excess or deficiency of caustic alkalinity.

Boiler Samples

(a) *Hardness.*—All suspended matter shall be removed by filtration. Then proceed as under (a) for treated water.

(b) *Alkalinity.*—Test same as (b) under Laboratory Methods, unless water is colored and Barium Chloride Method is indicated.

Barium Chloride Method. When a boiler water is colored, indicating the presence of organic material such as tannin, lignin, or decayed vegetable matter, false readings with methyl orange indicator are obtained. To offset the effect of this organic matter in the titration, the following method, although not absolutely accurate, should be used: 58.3 ml. of water is titrated in the usual way with *N/50* sulphuric acid, using phenolphthalein indicator. Call this reading *P*. A second sample of 58.3 ml. is then taken and 10 ml. of a 10 percent solution of neutral barium chloride $(BaCl_2)$ is added. This precipates the carbonate, leaving the caustic alkalinity. It is not necessary to filter. Titrate with *N/50* sulphuric acid, using phenolphthalein as an indicator. The end-point is reached when the pink color disappears for a few seconds. The reappearance of the pink color should be disregarded. The reading should be recorded as $P\,(BaCl_2)$.

$P\,(BaCl_2)$ = Caustic alkalinity in g.p.g. as $CaCO_3$.
$[P - P\,(BaCl_2)]^2$ = Carbonate alkalinity in g.p.g. as $CaCO_3$.
$2P - P\,(BaCl_2)$ = Total or methyl orange alkalinity in g.p.g. as $CaCO_3$.

(c) *Dissolved Solids.*—For boiler water analyses modern conductivity instruments and hydrometers are available from several manufacturers and with these it is possible to make rapid determination of dissolved solids with reasonable accuracy. When using these instruments manufacturer's instructions should be carefully followed and the instruments shall be calibrated at frequent intervals against gravimetric determinations. Conductivity instruments do not measure organic matter.

LABORATORY METHODS

The following methods may be used for routine laboratory procedure where it is desired to obtain quick results with accuracy sufficient to differentiate between constituents normally present in water, and to furnish sufficient information for making an ordinary analytical report which will permit the exercise of judgment as to the general effect of the quality of the water examined for boiler use.

Procedure

(a) *Total Dissolved Solids.*—Evaporate 58.3 ml. of the water under investigation (filtered, if necessary) to dryness in a weighed dish and heat the residue for 1 hour at 180 degrees C. Cool in desiccator and weigh. The number of milligrams will give total solids direct as grains per gallon.

(b) *Alkalinity.*—To a 58.3 ml. clear sample add two drops phenolphthalein indicator. If no pink color appears record P as zero. If pink color is present titrate with $N/50$ sulphuric acid in usual manner, recording burette reading as (P) alkalinity. To the same sample add methyl orange indicator. Continue titration with sulphuric acid without filling burette until first color change appears. Record reading as (M) alkalinity.

(Note. In any water analysis when phenolphthalein (P) and methyl orange (M) indicators are used one of the following conditions must exist):

1. When $P = 0$, then $M =$ total bicarbonate.
2. When P is less than $\frac{1}{2}M$, then $2P$ gives carbonate and $M-2P$ gives bicarbonate alkalinity.
3. When $P = \frac{1}{2}M$, then $2P =$ carbonate alkalinity.
4. When P is greater than $\frac{1}{2}M$, then $2P-M$ gives caustic and M minus caustic gives carbonate alkalinity.
5. When $P = M$, caustic alkalinity only is present.

(c) *Total Hardness.*—The approximation of the total hardness for comparative purposes should be made with soap test as outlined under (a) of Raw Water Tests.

(d) *Non-Carbonate Hardness.*—Boil 116.7 ml. of the water under examination in a 250-ml. Erlenmeyer flask for at least 15 minutes. From the results of hardness test, calculate the amount of soda reagent which will be necessary and add at least 10 ml. of the reagent in excess (usually 25 ml. is sufficient). Boil at least 10 minutes additional. Transfer to a 200-ml. graduated flask, cool, and make up to the mark with carbon dioxide free distilled water. Filter off 100 ml. and titrate the filtrate with $N/50$ sulphuric acid solution, using methyl orange indicator. Run a blank with 116.7 ml. of the distilled water, the same amount of soda reagent, and the same treatment. The difference in the amount of $N/50$ sulphuric acid solution required for neutralizing 100 ml. of the blank and 100 ml. of the sample gives the non-carbonate hardness directly as grains per gallon in terms of calcium carbonate. If the difference is negative it reveals the presence of sodium carbonate, or sodium hydroxide in amount expressed as grains per gallon in terms of calcium carbonate.

(e) *Magnesium.*—Take 116.7 ml. of the water under examination in a 250-ml. Erlenmeyer flask and exactly neutralize to methyl orange indicator, using $N/50$ sulphuric acid solution. Boil 15 minutes to expel all free carbon dioxide and add a solution of saturated lime water, so that, as shown by the hardness test, there will be at least 10 ml. in excess (usually 25 ml. is sufficient). Continue boiling for at least 10 minutes. Transfer to a 200-ml. volumetric flask, cool, and make up to volume with carbon dioxide free distilled water. Filter and titrate 100 ml. with $N/50$ sulphuric acid solution, using methyl orange indicator. Run a blank determination at the same time, using 116.7 ml. of distilled water and the same treatment with the same amount of saturated lime water. The difference between the amount of $N/50$ sulphuric acid solution required for neutralizing 100 ml. of the blank and 100 ml. of the sample gives the magnesium compounds present as grains per gallon in terms of calcium carbonate. (Note—If iron or aluminum salts are present in appreciable amount, they should be removed before applying this method.)

(f) *Sodium Chloride.*—To a 58.3 ml. sample of the water under examination add 2 drops of phenolphthalein. If there is any pink color discharge with $N/50$ sulphuric acid, then titrate with silver nitrate solution, using potassium chromate indicator. The result gives chlorides expressed as sodium chloride in g.p.g. Run blank on distilled water using same amount of indicator to determine correction.

(g) *Iron, Alumina, Silica.*—If the iron alumina and silica content is in excess of 1.0 grain per gallon, it may be well to separate and weigh by the usual gravimetric method. For rapid determination of these substances accurate photometric methods are available.

(h) *Sulfate.*—The gravimetric determination as barium sulphate may be made, but there are also available two rapid titration methods: namely, the benzidine and the tetrahydroxyquinone. The turbidimetric method is quite generally used.

(i) *Phosphate.*—To 5.0 ml. of water in a 50 ml. Nessler tube, add 40 ml. of distilled water, 0.5 ml. molybdate solution and 0.5 ml. sulfite solution. Make up volume to 50 ml., allow to stand 5 minutes and compare with standards. If color is darker than the 60 ppm standard, use a fractional sample.

Standards for Phosphate Determination

Solution 1—0.020 g. per liter brilliant blue.
Solution 2—0.028 g. per liter lake scarlet red.
Solution 3—0.140 g. per liter potassium chromate.

10 PPM Standard	*20 PPM Standard*	*30 PPM Standard*
9.5 ml. Solution 1	21.7 ml. Solution 1	36.5 ml. Solution 1
14.0 ml. Solution 2	32.0 ml. Solution 2	48.1 ml. Solution 2
8.0 ml. Solution 3	14.1 ml. Solution 3	24.0 ml. Solution 3

Mix and dilute to 500 ml.

40 PPM Standard	*50 PPM Standard*	*60 PPM Standard*
49.0 ml. Solution 1	66.7 ml. Solution 1	80.1 ml. Solution 1
57.8 ml. Solution 2	73.5 ml. Solution 2	86.3 ml. Solution 2
28.5 ml. Solution 3	34.3 ml. Solution 3	52.0 ml. Solution 3

Mix and dilute to 500 ml.

For use in Low Form 50 ml. Nessler tubes 6 inches by 1 inch.

(j) *Colorimetric Method for the Determination of Lignin.*—The analytical method here described depends on the reducing or oxygen-absorbing power of lignin and tannins. The tryosin reagent of Folin and Denis is reduced to give a blue solution of a color density that varies with the concentration of the lignin. The reagent is sensitive to small amounts of lignin and is therefore particularly suitable for boiler and feedwater analyses. This method has been carefully tested in the laboratory as well as on a number of samples from operating boilers and, in general, it should give satisfactory results. The method is rapid and simple so that it may be used as a routine procedure.

(1) Put 50 ml. of a filtered, clear, and cooled sample of boiler or feed water containing less than 20 ppm of sulfite waste liquor in a 100 ml. Nessler tube. If the water contains more than 20 ppm, a smaller sample should be taken and diluted to 50 ml.

(2) Make up 2 or 3 similar samples from the comparison solution to contain lower and higher concentrations of lignin than the unknown sample. They should also be diluted to a total volume of 50 ml.

(3) Treat each known and unknown with 2 ml. of the sodium tungstate-phosphomolybdic acid solution. Stir and allow to stand 5 min. Add 10 ml. of saturated sodium carbonate to each sample, stir and allow to stand 10 minutes.

(4) Match the blue color of the unknown with the knowns to estimate the amount of lignin.

Lignin comparison solution.—This solution represents the "standard" for the method and should be made up of exactly the same material that is fed to the boiler.

If waste sulfite liquors are used for the boiler feed they should contain about 50 percent dissolved solids. Weigh out a 10-gram sample from a well shaken representative

portion of the feed solution and dissolve in a liter of water. Pipette out 10 ml. of this solution and dilute to a liter. This latter solution is the comparison or standard solution and it contains 100 ppm of the 50 percent solution used in the boiler feed.

If powder obtained from waste sulfite liquor is used for the boiler feed, weigh out a 10-gram sample and dissolve in a liter of water. Pipette out 10 ml. of this solution and dilute to a liter.

Interference.—This method of analysis is free from interference by sulfate, silicate, chloride, phosphate, hydroxide, and sulfite, as well as most of the positive ions encountered in water samples. Ferrous iron will, however, cause interference. Fortunately, in most alkaline boiler waters the concentration is too low to cause difficulty. If a small amount of iron is present it may be desirable to allow the sample to settle for a few hours before an aliquot is taken for analysis. This will cause some oxidation of the iron and allow it to precipitate. The lignin itself will not suffer appreciable oxidation at room temperature. In the analysis of a few boiler water samples it has been found that there is a tendency for the slow precipitation of calcium carbonate. This carries down some lignin, and if the sample is analyzed immediately on removal from the boiler it shows higher concentration of lignin than it will show a few hours later. This sample may also be settled and filtered to avoid difficulty. To eliminate interference from both iron and calcium carbonate, a filtered, clear sample has been specified in the procedure.

The method of analysis suffers interference from some organic materials, especially phenolic compounds that might be present in some feedwaters. A blank should be run on the feedwater if appreciable interference is suspected. Highly colored boiler waters may also cause some difficulty.

Tannin materials, including cutch and quebracho, may also be determined by this method. The comparison solution should, of course, be made from the material fed to the boiler. One ppm of the tannins will produce as much color as 4 to 7 ppm of lignin In general it would not seem desirable to add lignins and tannins to the boiler feed simultaneously since this would complicate the analysis.

(k) *Calcium.*—To 116.7 ml. of water add 10 ml. of dilute *HCl* then add 5 ml. of a saturated oxalic acid solution, heat to boiling, slowly add dilute ammonium hydroxide (1:1) to slight excess; digest on a water bath, or hot-plate until the precipitate settles readily and leaves a clear supernatant liquid. Filter on an asbestos pad in a Gooch crucible. Wash beaker a few times with hot water from top to bottom, decanting washing water into the crucible. Wash the calcium oxalate precipitate on the crucible thoroughly with hot water. Return the crucible with the calcium oxalate to the beaker used for precipitation. Add sufficient boiling water to cover crucible, add 10 ml. of dilute sulphuric acid (1:1). Titrate with *N/25* potassium permanganate to a light pink color.

1 ml. of *N/25* potassium permanganate equals 1 grain per gallon of calcium in terms of calcium carbonate.

(l) *Carbon Dioxide.*—Titrate 58.3 ml. of the sample with *N/50* sodium carbonate solution, using phenolphthalein indicator. Result in milliliters will give grains per gallon in terms of calcium carbonate. Run sample as quickly as possible. For free CO_2 as ppm multiply ml. of *N/50* sodium carbonate by 7.5.

(m) *Photometric Method.*—Instruments and solutions are now available which by colormetric and turbidimetric methods rapidly determine the various constituents usually found in water.

Reporting of Results

The following methods can be used in calculating hypothetical combinations in average waters:

(a) If the non-carbonate hardness exceeds the magnesium, then the magnesium is present as magnesium sulfate. Calculate the remainder of the non-carbonate hardness to calcium sulfate. The alkalinity is then due entirely to calcium bicarbonate and expressed as g.p.g. in terms of $CaCO_3$.

(b) If the non-carbonate hardness is less than the magnesium, calculate the non-carbonate hardness to magnesium sulfate and the remainder of the magnesium to magnesium carbonate. The magnesium carbonate is subtracted from the total alkalinity. The difference between the total alkalinity and the magnesium carbonate is then reported as calcium carbonate in g.p.g. expressed as $CaCO_3$.

(c) If the hardness is less than the total alkalinity, then the magnesium is present as magnesium carbonate, the calcium as calcium carbonate and the difference between the hardness and the total alkalinity is sodium carbonate.

(d) If the total alkalinity is zero, as in the case of acid waters, then the total hardness is calcium and/or magnesium sulfate and/or chlorides.

(e) The difference between the total dissolved solids and the sum of magnesium sulfate, magnesium carbonate, calcium sulfate, calcium carbonate, sodium chloride, sodium carbonate, iron and aluminum oxides, and silica, gives the amount of non-incrusting sulfates, nitrates and organic matter. If the difference is negative, the result indicates calcium and magnesium chlorides or nitrates in which case it will be necessary to make the sulfate determination to secure the most probable hypothetical combination.

FULL AND COMPLETE LABORATORY EXAMINATION

For full and complete examination of waters as may be required in special cases, it is recommended that procedure be used as outlined in the latest edition of Standard Methods of Water Analysis, published by the American Public Health Association, in collaboration with the American Water Works Association and the American Chemical Society.

Report on Assignment 1

Revision of Manual—Revised Specifications for Cast Iron Pipe

H. F. King (chairman, subcommittee), R. C. Bardwell, W. L. Curtiss, G. E. Durham, R. N. Foster, J. P. Hanley, R. L. Holmes, A. W. Johnson, Ray McBrian, G. F. Metzdorf, R. H. Miller, W. G. Powrie, W. A. Radspinner, O. T. Rees, J. E. Tiedt, C. P. Van Gundy, H. W. Van Hovenberg, J. B. Wesley.

This report is presented as information but includes a recommendation for adoption and publication in the Manual.

After studying various specifications for cast iron pipe, the conclusion reached by the committee is that the American Standards Association Specifications, A–21.2–1939, covering cast iron pit-cast pipe should be adopted by the AREA as recommended practice by title reference. These specifications were developed under the joint sponsorship of the American Gas Association, the American Society for Testing Materials, the American Water Works Association and the New England Water Works Association.

The subject matter of the present specifications in Vol. 23 and the tables in Vol. 34 have been changed to a considerable extent, particularly the paragraphs on tests of material, test bars and Talbot strip tests, which are covered in great detail in the revised specifications.

The principal change has been made in the classes of pipe. The old specifications used classes A, B, C, D, etc. for static pressures of 43, 86, 130 and 178 lb. per sq. in. respectively. The new classifications refer to classes 1, 2, 3, 4, to 11, inclusive, starting with Class 1 as the base class. Each class is made eight percent heavier than the preceding class. Class 1 is computed for 50 lb. static pressure, plus water hammer, with trench load for cover of five feet, field conditions being a flat bottom trench with tamped backfill. Class 2 is computed for 100 lb. static pressure, and so on, at 50-lb. intervals. The classes are also referred to in one of the new tables as Class 50 for 50 lb. pressure, Class 100 for 100 lb. pressure, and so on.

Complete copies of these specifications A–21.2–1939 may be obtained in pamphlet form from the Secretary of the AWWA, 22 East 40th Street, New York City.

However, any railway that desires to use centrifugally cast pipe or pipe with bolt lugs and integral machine-tapered joints may use Federal Specification WW–P–421 dated July 21, 1931, together with WW–P–421, Amendment No. 3, dated April 26, 1940. The above federal specifications cover all types of cast iron pipe in general use and may be obtained in pamphlet form from the Superintendent of Documents, Washington, D. C.

The committee, therefore, offers the following recommendation:

Under the heading Specifications for Cast Iron Pipe and Special Castings on Manual page 13–15, delete the paragraph reading as follows:

Present Form

Adopted by the American Water Works Association May 12, 1908; reprinted by permission in 1922 Proceedings of the AREA, Volume 23, pp. 514, 1112. See also Volume 34, 1933, pp. 82, 863, for tables showing detailed weights and dimensions for various classes of cast iron pipe and fittings.

and replace it with the following paragraph:

Proposed Form

Cast iron pit-cast pipe shall conform to American Standards Association Specifications, A–21.2–1939, published by the American Water Works Association, 22 East 40th Street, New York.

Report on Assignment 2

Cause of and Remedy for Pitting and Corrosion of Locomotive Boiler Tubes and Sheets With Special Reference to Status of Embrittlement Investigations

R. E. Coughlan (chairman, subcommittee), R. C. Bardwell, W. M. Barr, W. L. Curtiss. J. H. Davidson, G. E. Durham, E. M. Grime, H. M. Laudemann, J. J. Laudig, Ray McBrian, A. B. Pierce, O. T. Rees, R. M. Stimmel, C. P. Van Gundy, J. B. Wesley.

This report is submitted as information.

During the past year your committee has been investigating the result of experiments at the United States Bureau of Mines and at several industrial laboratories, as well as practical work on one of the railroads, in connection with the use of sodium nitrate as an inhibitor for inter-crystalline corrosion. This particular railroad, due to a combination of circumstances, was having considerable difficulty in securing complete

elimination of inter-crystalline corrosion by the use of sulphite liquor, and it was found that the introduction of sodium nitrate appeared to give much better results. It was also noted that the use of sodium nitrate was more easily controlled and a definite concentration in the boiler water could be maintained without difficulty. Inasmuch as this particular test is still in progress, the final results as to the use of this material in railroad service will be reported at a later date.

The work at several of the industrial laboratories during the past year has shown there is no definite proof that inorganic salts, ordinarily found in boiler waters, exert any pronounced protective action. This work also has developed the fact that the presence of a higher sulfate content in a boiler water interferes with the protective action of lignin.

Further work shows that increasingly larger amounts of inorganic inhibitors are required in the feedwater as the number of concentrations increase in the boiler. It was also found that sodium nitrate is particularly effective as an inhibiting agent in the presence of organic lignin compounds.

The use of the embrittlement detector, as previously reported by your committee, is still believed to be a decided asset in these studies.

Definite results on the use of sodium nitrate alone and in combination with organic lignin materials should become available during the coming year.

Report on Assignment 4

Progress Being Made by Federal or State Authorities on Regulations Pertaining to Railway Sanitation

Collaborating With Joint Committee on Railway Sanitation, AAR

H. W. Van Hovenberg (chairman, subcommittee), R. C. Bardwell, C. W. Brown, C. B. Bryant, R. E. Coughlan, J. H. Davidson, A. W. Johnson, C. R. Knowles, O. E. Mace, W. A. McGee, G. F. Metzdorf, E. R. Morris, Theodore Morris, M. F. Neuzil, A. B. Pierce, W. G. Powrie, W. A. Radspinner, C. P. Van Gundy, R. E. Wachter. J. B. Wesley.

This report is offered as information.

The committee has been advised that regulations pertaining to railway sanitation are being considered by a committee of the U. S. Public Health Service with a view of making substantial revisions which may have an appreciable effect on many of the present practices and installations at various railroad terminals. This subject has been referred to the Joint Committee on Railway Sanitation, composed of representatives from the Medical and Surgical Section and the Mechanical Division of the AAR, as well as three representatives from the Engineering Division. It is understood that this joint committee will confer with the representatives of the U. S. Public Health Service before definite action is taken.

The committee also has a representative, carrying pertinent instructions from Committee 13, on a special committee composed of various federal organizations and scientific associations which was appointed by the surgeon general of the U. S. Public Health Service to revise the Treasury Drinking Water Standards. This proposed revision is also a matter of some concern to the American railroads.

Report on Assignment 5

Principal Activities of the Fire Protection and Insurance Section of the Association of American Railroads

W. A. Radspinner (chairman, subcommittee), H. F. King, G. F. Metzdorf.

The following report on the activities of the Fire Protection and Insurance Section, AAR, is presented as information.

Statistics of railway fire losses in 1940 were recently issued by the Section in its September News Letter. They show that, whereas the loss in 1920, when the railroads initiated a serious effort to prevent fires, was $54.40 per mile, the loss in 1940 was only $12.96 per mile. This is surely a worthwhile improvement which more than justifies the organizations maintained by the railroads in the interest of fire protection and prevention.

The 1940 report of fire losses reveals that there were:

87	fires in fire resistive buildings and contents	$ 130,500
1,132	fires in non-fire resistive buildings and contents	1,735,964
251	fires in bridges, trestles and culverts	243,499
311	fires in ties, poles, piling and other lumber	33,543

The report shows also that 113 fires were caused by work trains at a loss of $48,972.

It is also of interest to note that out of 34 listed causes of fires on railroads, the first ten show:

23.8 percent, cause unknown
11.77 percent, by trespassers
8.63 percent, by smokers (matches and cigarettes)
8.46 percent, by exposure to adjoining property fires
8.24 percent, by sparks from locomotives
3.76 percent, by coal and wood stoves
3.68 percent, by spontaneous ignition
2.74 percent, electric power and motors
2.57 percent, unclassified
2.00 percent, burning right-of-way

The Fire Protection and Insurance Section Hand Book of Railway Fire Protection is now being edited, and should be off the press before the end of 1941. This handbook deals with fire protection of railways in such a manner that it will be very useful to both the engineer and the layman. Orders for this book should be placed with Mr. W. F. Steffens, Secretary, FP&I Section, AAR, 230 Park avenue, New York City.

Report on Assignment 6

Use of Anti-Foam Compounds to Reduce Road Blowing

J. H. Davidson (chairman, subcommittee), W. M. Barr, W. E. Bickel, C. W. Brown. R. W. Chorley, R. E. Coughlan, R. N. Foster, J. P. Hanley, C. K. Holden, R. L. Holmes, H. M. Laudemann, J. J. Laudig, O. E. Mace, H. L. McMullin, M. F. Neuzil, S. E. Printz, O. T. Rees, R. M. Stimmel, J. E. Tiedt, K. J. Weir, J. B. Wesley.

The following discussion is presented as information.

For many years one of the most troublesome factors in locomotive operation has been the foaming and priming of water in the boilers. Because so many different explanations have been offered for the causes of foaming and because very erratic and unpredictable cases of foaming still occur, foaming and priming are still referred to as "the least understood of boiler phenomena".

Since both foaming and priming result in carryover, that is, the carrying along of liquid water in the steam, it is easily understood why there has been much confusion in the use of these terms, with resultant contradictory experiences reported. In an attempt to differentiate between these two phenomena, the following definitions and comments have been suggested by your committee.

Foaming and Priming Defined

Foaming is the term applied to the action in a boiler when steam bubbles build up over the surface of the water to form a layer of foam which fills the steam space and carries over into the cylinders. This action is due to the amount and type of impurities present in the water. The impurities which concentrate and cause foaming are dissolved solids and suspended matter, either of which may be of organic or inorganic origin. These impurities seem to increase the strength or tenacity of the thin films surrounding the steam bubbles, and as the bubbles rise to the surface, they retain their films and collect to produce foam. The concentration of impurities reaches a critical point, depending upon the type and work of the locomotive boiler, the amount and character of the alkali salts, and the amount and type of suspended matter in the water. To prevent foaming the concentration must be kept below this point by systematic blowing off of boilers, either manually or automatically. The cost of maintaining the concentration below the critical point, equals the cost of pumping, treating, and heating to boiler temperature the amount of water blown out. When the concentration of foaming salts is so great that it is impractical or uneconomical to blow off the necessary amount of water, anti-foam compounds may be used with good results.

Priming is the term applied to the instantaneous evolution of steam from a heating surface, which suddenly carries water in large volumes into the steam space. This action is mechanical and may be due to poor design of the boiler, a sudden opening of the throttle, or working the boiler beyond its capacity. It is independent of the character of the water. While the effect upon the locomotive is temporarily the same, priming differs from foaming in that it can be mechanically controlled to a large extent by proper operation.

From the above it is apparent that true foaming as distinguished from priming, is due to the quantity and quality of the impurities in the water. Experience and research seem to indicate that the quality of the impurities in the water and especially the relative proportions of the various impurities are of more importance than the mere total quantity of them. However, until we do know more definitely the role of each of these

factors in producing foaming, we can use the total dissolved solids as a sort of yardstick to measure the foaming tendency of boiler waters. In fact in the majority of waters the tendency to foam is almost a straight line function of the total dissolved solids. Since these solids can be easily and quickly determined, it is customary for water conditioning chemists to use this determination to indicate the critical point at which foaming may be expected to take place.

Influence of Dissolved and Suspended Solids

For instance, experience has shown that foaming is not usually encountered until the total dissolved solids in the boiler water have reached a concentration of from 125 to 200 grains per U. S. gallon. It is true that there are many exceptions to the above rule; for instance, the water may contain some certain kind of organic matter which may either aggravate or destroy the tendency to foam, or the relative proportions of certain salts may be such that variations are caused so that frequently cases of foaming may be reported with total solids below the limit stated above, and on the other hand much higher concentrations are frequently carried with no foaming trouble. There is also evidence of some relationship between the number of times a water is concentrated and its foaming point, for example, waters of low concentratable solids will carry over at lower total concentrations than will waters of high concentratable solids.

In spite of these and many other special cases which may arise from time to time, the fact remains that the total solids is at present our most dependable and convenient method of evaluating and controlling the tendency of boiler water to foam.

Having determined the critical concentration at which foaming occurs for any particular type of locomotive, working under fairly uniform conditions on a certain division, then the question arises as to what method of controlling the foam will be the most desirable. As previously stated, we have the choice of two methods. The dissolved and suspended materials in the boiler water may be kept safely below the critical point by systematic blowing of the boiler or anti-foam compound may be used.

Before the science of water conditioning for locomotives had reached its present advanced stage, it was customary for railroads operating in bad water districts to wash and clean boilers or change water after each trip over a division in order to keep down the accumulation of scale and mud. Since a more scientific study of locomotive water supplies has been made, with the elimination of many objectionable supplies and the proper conditioning of the water, many railroads have extended their washout periods to 30 days, and have in most cases been successful in controlling the foaming by systematic blowing off of boilers both on the road and at terminals. Information collected by this committee indicates that this is by far the most widely used method of controlling foaming and the records show that many roads which at one time used large quantities of anti-foam compound no longer depend on it and the consumption of anti-foam compound has decreased materially in the past ten years.

Castor Oil

Long ago it was discovered that a few thousandths of one percent of castor oil will control most cases of true foaming within certain limits. The result is not permanent, and therefore the oil has to be added continuously to the water in the boiler, and once started, its use must be continued until boiler is washed out. Overdosages react harmfully in causing the boiler to become "compound dirty" and actually increasing the foaming tendency. In order to apply the small quantities of oil required it is usually prepared in the form of an emulsion with various percentages of tannin extract. The percentage of castor oil varies from about 10 to 20 by weight. The prescribed quantity is usually dissolved in hot water and placed in the tender tank just before taking water.

Just how the castor oil works to prevent foaming is not yet clearly understood and while it is quite effective in most cases of true foaming, occasionally cases have been reported where it had little effect. The cost of compounds varies from about 6 to 15 cents per pound and they are used in the proportion of one pound of the compound to from 4,000 to 12,000 gal. of water. Experience has shown that even with the use of anti-foam compound a critical concentration is finally reached beyond which the compound is not effective and then it is necessary to resort to blowing off or changing of the water. Roughly speaking, the use of compound will permit an increase of from 75 to 100 percent in the amount of dissolved solids that can be carried before foaming is encountered. It is evident from the above that such compounds will not prevent foaming, but will postpone the time at which foaming occurs, and that whether or not anti-foam compound is used, blowing off must be resorted to if any considerable mileage is to be made between water changes or washes. This explains why most roads operating with 30-day washout periods prefer to depend entirely on blowing to control foaming.

In these references to anti-foaming compounds it should be distinctly understood that we are referring to the conventional type of compound which depends upon castor oil for its effectiveness. During the past year experiments have been carried on with various organic materials which have in some cases made it possible to operate locomotive boilers with high concentrations of soluble salts and suspended matter without trouble from foaming. The action of these materials is entirely different from that of castor oil and they should be considered as water conditioning chemicals rather than as anti-foam compounds in the generally accepted sense. At present we do not have sufficient information concerning these materials to make any definite recommendations concerning their use. However, judging from some of the results obtained to date, they promise to develop into a very valuable addition to our present methods of water conditioning.

A Complex Problem

Summing up what we have learned by research and experience concerning foaming and the various methods of controlling it, we must admit that it is an extremely complex problem which presents some questions which have not yet been answered to our satisfaction. Therefore it is impossible to set forth a rigid recommendation which will be applicable to all cases. Where water of fairly good quality has been properly conditioned, undoubtedly the most satisfactory method is to control foaming by systematic blowing.

Under some conditions it may be uneconomical or impractical to depend entirely on blowing. For instance, there are some districts where the quality of the water, the type of locomotive and the tonnage handled are combined in such a way that the boiler cannot furnish all the steam required to do its work and at the same time permit sufficient water to be blown off to control foaming. Also, at times an actual shortage of water exists on certain districts and it is advisable under such circumstances to reduce blowdown to a minimum. Again there are districts where it is impossible to obtain any water excepting that containing extremely high concentrations of soluble salts, so that the water when delivered to the tender tank at terminals or intermediate stations is practically at the critical point before any further concentration takes place in the boiler. Obviously in such special cases as these the use of anti-foam compound would be economical.

While the quality of water supplies to locomotives on our railroads is steadily being improved by the elimination of undesirable supplies and proper conditioning of the remaining supplies, making it more and more advantageous to control foaming by

proper systematic blowing off of boilers, there will probably exist for some time, conditions which make it very desirable to use anti-foam compound. Like any other engineering problem, a few carefully made and interpreted tests should enable the supervisors to determine the most economical and satisfactory method to follow.

Report on Assignment 7

Specifications for Welded Steel Tanks for Water Service

Collaborating With Committee 15–Iron and Steel Structures and the American Welding Society

A. W. Johnson (chairman, subcommittee), W. L. Curtiss, P. W. Elmore, F. A. Feikert, J. P. Hanley, C. K. Holden, J. J. Laudig, Ray McBrian, W. A. McGee, S. E. Printz, H. E. Silcox, J. E. Tiedt, H. W. Van Hovenberg, K. J. Weir.

Your committee presents for adoption and publication in the Manual, specifications for welded steel water tanks. In the preparation of these specifications your committee was assisted by Messrs. H. O. Hill, H. C. Boardman and J. O. Jackson, representing the American Welding Society, and also AREA Committee 15—Iron and Steel Structures.

Introduction

For approximately 40 years railways have been using riveted steel tanks for water service. Within the past eight years the welded steel tank of both standpipe and elevated type has, due to improved welding methods, gradually come into use and today it is one of the best and most economical types of water storage tank available. The first cost of an all-welded standpipe type flatbottom tank 24 ft. in diameter by 60 ft. high is about 20 percent less than a riveted tank of the same size. The welded tank offers the further advantage that it can be dismantled and re-erected at less cost than a riveted tank.

SPECIFICATIONS FOR WELDED STEEL TANKS FOR RAILWAY WATER SERVICE

1. GENERAL

101. Scope of Specifications

These specifications apply to the construction of fusion arc welded steel water storage tanks.

102. Definitions

Standpipe.—A flat bottom cylindrical tank having a shell height greater than its diameter.

Reservoir.—A flat bottom cylindrical tank having a shell height equal to or less than its diameter.

Elevated Tank.—A cylindrical tank supported on a tower.

103. Weather

When weather conditions are adverse, as in the case of snow, rain or heavy winds, the work shall be protected. No welding shall be done when the temperature of the metal is less than 20 degrees F.

104. Drawings

Detailed plans shall accompany specification showing type of tank, general dimensions, ladders, manholes, pipe connections, water level gage, frostproofing, other accessories and type of foundation. The Contractor shall submit with his bid plans showing details of tank construction covered by his proposal.

105. Foundations

The foundation for the tank shall be provided by the Railway Company unless otherwise specified in the contract. Detailed working drawings for foundations of elevated tanks only shall be furnished by the tank Contractor to suit permissible soil pressures determined by the Railway Company. The tank Contractor shall furnish anchor bolts where necessary.

2. MATERIALS

201. Quality of Metal

All steel shall be made by the open hearth or electric process and shall conform to the current ASTM Specifications A–7, A–10, or A–78. Copper bearing steel with not less than 0.20 percent copper shall be used when specified.

202. Filler Metal

Electrodes shall conform to the AWS–ASTM Specifications for Iron and Steel Arc Welding Electrodes, Serial Designation A–233 of the latest revision, using the following classifications.

E–6010, E–6011, E–6012, E–6013, E–6020, E–6030.

The classification number selected must be suitable for the electric current characteristics and also for the position of welding.

3. DESIGN

301. Type of Joints

Joints shall be either butt welded or lap welded as specified.

302. Design Loads

The dead load shall be the estimated weight of all permanent construction and fittings, 490 pounds per cubic foot for steel and 150 pounds per cubic foot for concrete.

The weight of water shall be assumed to be 62.5 pounds per cubic foot.

20 pounds per square foot of vertical projection shall be used for wind load.

The snow load shall be 25 pounds per square foot of horizontal projection on the roof.

303. Unit Stresses

(a) Plates and structural members.

	Pounds Per Square Inch
Tension and compression	15,000
Shear	11,250

(b) Single or double butt welds, with complete penetration.

Tension	12,750
Compression	15,000
Shear	10,000

A

(c) Double welded fillet welds.
Shear—8,000 pounds per square inch.
Note: Stress in a fillet weld shall be considered as shear on the throat, for any direction of the applied load. The throat shall be assumed as 0.707 times the short leg.

304. Plate Thickness

Roof $\frac{3}{16}$ inch minimum
Shell or down take tube ¼ inch minimum
Bottom ⅜ inch minimum
Lap welds ½ inch maximum
Field welds 1½ inch maximum

305. Reinforcement Around Openings

Openings in tank shall be reinforced 100 percent, i.e., the area put back around the hole shall equal or exceed the area cut out to make the hole. Necks of attachments, such as nozzles and manhole frames, shall not be considered as reinforcements.

306. Cylindrical Rings

Plates shall be rolled to proper radius in accordance with the following table:

Plate Thickness (Inches)	*Minimum Diameter for Which Plates Need Not Be Rolled (Feet)*
Less than ⅜	30
⅜ to less than ½	60
½ to less than ⅝	120
⅝ and heavier	Must be rolled for all diameters.

307. Tank Support

For suspended bottom tanks, the steel substructure shall conform to AREA Specifications for Steel Railway Bridges, except that allowance shall be made for wind but not for impact.

4. WELDING

401. Definitions and Symbols

Welding terms shall be as given in the latest edition of "Definitions of Welding Terms and Master Chart of Welding Processes" issued by the American Welding Society.

Welding symbols shall be as shown in the latest edition of "Welding Symbols and Instructions for Their Use", issued by the American Welding Society.

402. Qualifications of Welding Procedure and Testing of Welding Operators

Welding procedure shall be qualified and welding operators shall be tested according to the latest rules of the American Welding Society for "Standard Qualification Procedure", using the suggested test values contained therein.

403. Flat Tank Bottoms Resting Directly on Grade or Foundation

Butt Welded Construction

Bottom plates shall be single welded from the top side with complete penetration, using backing up strip ⅛ inch thick or heavier, tack welded to one plate. No plates will be welded until all plates are in place. Care shall be taken to prevent distortion of plates during welding.

Lap Welded Construction

Plates shall be reasonably rectangular, square-edged, of dimensions to provide laps at least 1¼ inches. Marginal sketch plates under the bottom ring shall have the outer end of the joint "fitted" and butt welded to form a smooth bearing under the shell. Welding shall be on the top side only with a continuous full-fillet weld on all seams.

404. Shell to Bottom Joint

For flat bottom tanks the attachment between the bottom edge of lowest course side sheets and the bottom sketch plate shall be continuous fillet welds on both sides of side sheets. The size of each weld measured along the surface of either plate shall be not less than the thickness of the thinner plate. The sketch plates shall extend outside the tank shell a distance of at least one inch beyond the toe of the weld.

405. Butt Welded Joints

Vertical joints in the side sheets of tanks and all joints in suspended bottoms and riser pipes shall be double butt welded to insure complete penetration or single butt welded, with suitable backing-up strip or equivalent means to insure complete penetration. Horizontal joints shall have not less than two-thirds penetration based on the thickness of the thinner plate, with the unwelded portion located substantially at the middle of the thinner plate.

406. Lap Welded Joints

Vertical joints in side sheets of tanks and all joints in suspended bottoms, and in riser pipes shall have continuous full fillet welds both inside and outside with a lap not less than five times the thickness of the thinner plate. Horizontal joints shall have continuous welds both inside and outside which must develop a strength of at least two-thirds that of a full double fillet welded lap joint.

407. Roof Welds

Roof sheets shall be butt or full fillet lap welded, on the top side only with a continuous weld on all seams.

408. Intermittent Welds

Intermittent butt welds shall not be used.

Intermittent welding shall not be used in tank shell plating. The length of any segment of intermittent weld shall be not less than four times the weld size with a minimum of 1½ inches. All seams of intermittent welding shall have continuous welds at each end of at least 6 inches.

409. Minimum Size Fillet Welds

Plates $\frac{3}{16}$ inch and less in thickness shall have full fillet welds. Plates over $\frac{3}{16}$ inch in thickness shall have welds not less than one-third the thickness of the thinner plate at the joint with a minimum of $\frac{3}{16}$ inch. Sealing shall be by applying a continuous weld. The length of any weld shall be not less than four times the weld size with a minimum of 1½ inches not including tapered ends. A deduction of at least ¼ inch shall be made from the overall length for tapered ends.

410. Scaffolding Holes

Holes made for scaffolding shall be entirely filled with weld metal applied from both sides of the tank shell, uniform in size and surface.

5. TESTING AND PAINTING

501. Testing

Flat bottom tanks shall have the bottom and first side course erected on horses, or on the tank foundation and jacked up, and tested with water for leaks. All leaks shall be repaired and the underside of the bottom shall be painted before lowering on to foundation. Upon completion, the entire tank shall be tested by filling with water. All leaks shall be repaired by cutting out welds and rewelding. The tank shall be empty or the water level shall be at least two feet below the point being repaired.

502. Painting

The steel shall be shipped without painting.

After the tank is completed and tested it shall be thoroughly cleaned with a wire brush or sand blast and painted or treated with a metal preservative as specified by the Railway Company.

6. ACCESSORIES AND FITTINGS

601. Minimum Size of Manholes

Shell—18 inches by 24 inches elliptical, or 24 inches diameter circular

Roof—30 inches by 30 inches

602. Ladders

Full height inside and outside ladders and a revolving roof ladder shall be furnished and installed.

Side rails ⅜ inch by 2 inches minimum

Ladder rungs ¾ inch minimum diameter

603. Indicator

An indicator shall be furnished and installed for the full height of the tank complete with a suitable float, target and bronze metal sash chain.

604. Overflow and Vent

Where specified a 3 inch overflow pipe shall be installed below the top angle extending 12 inches beyond the tank shell.

Tanks with roofs shall have a suitable vent other than the overflow pipe.

605. Pipe Connections

Pipe connections of sizes and location specified shall be made either by welding pipe with standard flanges at each end through the tank with suitable reinforcing, or by welding both inside and outside threaded tank flanges to the tank.

606. Landing Platform

Where roof ladders are not provided a suitable landing platform, extending out from the top of the tank, shall be constructed when specified.

607. Downtake Tube Bracing

The inside of the tank shall be equipped with radius rods or angles to support the downtake tube. In event a downtake tube is not installed, scaffold lugs or other means shall be provided for painting and cleaning the tank.

Report on Assignment 8

Methods for Cleaning Sewers and Underground Pipe Lines

R. E. Wachter (chairman, subcommittee), W. E. Bickel, R. W. Chorley, J. H. Davidson, G. E. Durham, P. W. Elmore, E. M. Grime, C. K. Holden, H. F. King, C. R. Knowles, O. E. Mace, H. L. McMullin, R. H. Miller, E. R. Morris, A. B. Pierce, S. E. Printz, H. M. Schudlich, H. E. Silcox, J. E. Tiedt, C. P. Van Gundy, K. J. Weir.

Your committee submits the following report as information.

GENERAL

Decrease in the flow capacity of pipe lines is due to incrustations or deposits of waste, mud or suspended matter; corrosion; tubercles; vegetable growth; and, insoluble compounds formed by reason of temperature change or chemical reaction within the pipe lines, the latter condition obtaining especially in treated water lines.

Relatively few instances occur where these lines cannot be cleaned in place, and only in exceptional cases is it found necessary to take up major portions of the pipe lines to remove stoppage or deposits. The choice of methods cannot well be made a rule, but depends on the conditions found in any particular case, such as the extent of deposit, composition, degree of hardness, size and accessibility of the underground line, time and costs involved, and importance of maintaining service during cleaning operations.

Restoring sewers and other underground pipe lines, otherwise in good physical condition, to maximum flow capacity is generally accomplished by either mechanical or chemical means. Mechanical cleaning has been found satisfactory and effective in most cases. Chemical solvents have a definite advantage over mechanical means, where the pipe line is difficult of access, has a large number of bends, and only short sections of straight pipe. Where the opposite is true, mechanical scrapers or cutters are usually more economical.

CLEANING SEWER LINES

Sewer lines are affected principally by deposits building up from the bottom, or flow line. Entire stoppage may be caused by vegetation, particularly roots entering at defective joints and expanding rapidly. Unless the cause can be eliminated, it is usually found more economical in the end to provide cast iron or other pipe of similar quality with durable and tight joints.

Normally sewer lines are provided with manholes from 300 to 400 ft. apart which provide ready access to the pipe lines. Vitrified pipe generally used is not capable of withstanding internal pressures to any great extent. Therefore, it is not recommended that pressures in excess of those encountered in a gravity flow sewer be used in cleaning them.

Mechanical Methods

Sewer rods of wood, having metal couplings at each end, are inserted into the sewer line at the upgrade manhole, and connected to form a rod of sufficient length to reach the next lower manhole. Buoyancy permits taking advantage of floating the rods in the direction of flow. A cable of sufficient strength may then be put through the pipe line to operate a scraper or cutting tool, which is pulled through with the assistance of a hand winch placed at the ground surface, and manually operated. It is customary to use

one hand winch at each of the extremities so that after detaching the cleaning tool at the lower end, the cable can be readily pulled back and the operation repeated, when necessary.

Spiral cutters attached to water hose, propelled by water pressure, which also revolves the cutter head, may be successfully used to dislodge some root growth or other obstructions. The main discharge from the cutter head is directed backwards, washing the loosened particles toward the manhole. The starting point of operations, is usually at the downgrade end of the stoppage, work proceeding upgrade so that all waste is carried away in the portion of the sewer which is clear of obstruction. In exceptional cases or where the obstruction is confined to short limits and is close to the upgrade manhole, it may be found feasible to work downgrade.

Flexible steel bands, and coil spring cables are used to advantage in clearing some obstructions. The limit of operation by this means is not much in excess of 100 ft.

Ball floats find use where a sandy or relatively easy scouring material is lodged in the line. The ball is smaller than the diameter of the pipe line. By restricting the flow area, and forcing the flow along the bottom of the pipe, due to the buoyancy of the float, bottom deposits are scoured away. In order to retain control of the float it is advisable to attach it to a cable so that it can be removed from the line, if obstructions will not yield, or when the float is prevented from moving forward.

Chemical Method

The use of chemicals to dissolve grease, soap, paper and other organic matter is limited generally to bends, fittings, small size pipe and such lines as are not readily accessible or where it is not practicable to employ mechanical means.

These solvents are usually proprietary preparations sold in tight containers of limited weight to prevent deterioration. Admitted to the line affected at a selected opening above the point of deposit, the chemical carries on its solvent action with little or no evidence of the cleaning accomplished, except what may be estimated from the increased flow capacity. Applications of solvent are made at intervals, as the stoppage may require it.

CLEANING OTHER UNDERGROUND PIPE LINES

Other underground pipe lines are usually capable of resisting internal pressures of not less than 100 lb. per sq. in., and this makes it possible to use relatively high water pressure to aid in the cleaning process.

Mechanical Method

The mechanical method is used extensively and is generally the more economical and speedier method. Scrapers and cutting tools with stationary or revolving blades are attached to wire cables and by means of water pressure alone or aided by a hand operated winch, and water pressure, are propelled through the pipe line. The procedure commonly employed is as follows:

Water pressure is shut off from the portion of the line to be cleaned.

Short sections of pipe, approximately 3 ft. long, are removed at the extremities of this portion of the line, which may reach a length of 1,000 ft. or more, depending on the number of bends and the extent and nature of the incrustation.

A $\frac{3}{16}$-in. cable and carrier fastened to it is inserted into the pipe at the opening nearest to pressure supply, following which the opening is temporarily closed by inserting a piece of pipe fitted with a small opening directed upward at about 45 deg., large enough to permit the largest size cable used to pass through freely.

Water pressure is turned on, forcing the carrier and small cable to the next opening.

Water pressure is again turned off.

A larger cable, usually ⅜-in. diameter steel, is then fastened to the $\frac{3}{16}$-in. carrier cable, and pulled through the pipe by means of the hand winch.

The temporary closure is removed, the cleaning machine is attached to the ⅜-in. cable and inserted into the pipe.

The temporary closure is again made.

Water pressure is turned on and the cleaning machine is propelled entirely by water pressure or dragged through the pipe line, the pull on the hand winch being aided by the pressure of water behind the cleaning machine.

The cuttings or waste matter are washed ahead of the cleaning machine by the water passing through it to the next opening, where they are flushed to the surface of the ground and disposed of. When the cleaning machine arrives at the end of its travel, the water pressure is turned off. The excavation is unwatered, using a diaphragm or other pump, capable of handling the solids encountered. Hand operated or powered pumps are used, depending on the extent of the work.

Where flooding of the ground surface in the vicinity is likely to cause damage, a temporary pipe extension of suitable length is made to carry the water and waste to a safe point for disposal. In the latter event, it is advisable to provide a cable way opening through the side of the temporary pipe extension similar to that provided at the other opening, and using a cable attached to both ends of the cleaning machine in order to facilitate repetitions of the cleaning operations which are frequently found necessary to remove all deposit completely.

Where incrustations are relatively heavy, several sizes of cleaning tools are used, starting with the smallest and increasing to the size which leaves the interior of the pipe clean and smooth. Some incrustations yield readily and can be entirely removed with one operation of the tool.

Cleaning equipment has recently been developed which has given satisfactory results with moderate water pressures. This equipment consists of a power unit, a flexible steel rod, and several types of cutter heads, all mounted or housed on a truck. The appropriate cutter head, fastened to the flexible steel rod is inserted into the pipe line at a selected location where a portion of the line has been previously removed. The pipe cut is left open. Cleaning or cutting operations proceed as the power unit rotates the flexible steel shaft and cutter head, at the same time pushing the shaft and head forward, against the flow or water pressure in the pipe line. Cuttings and water are washed back to the open cut and disposed of.

By this method it has been possible to clean 2,400 ft. of pipe line from one cut, working both ways therefrom, or up to the limit of the 1,200 ft. of steel shaft available. Equally good results were achieved by working against tank pressures in one direction, and against pump pressures in the opposite direction from the cut.

The flexible steel rod and cutter heads are adapted for cleaning pipe lines ranging from 2 to 40 in. in diameter. There are concerns, which contract the furnishing of cleaning machines, on basis of rental per day, or length of pipe line involved. The service may be had with or without superintendence, but in either case the owner of the pipe line defrays the costs incidental to excavation, pipe line cuts, material and other equipment needed, and the disposal of waste.

Some types of cleaning equipment may be purchased outright and this may be found advantageous where adaptability, extent and frequency of cleaning warrants it.

The cleaning of water pipe lines with pressure type machines has been widely used in the railway and municipal field since 1910 for sizes 6 in. and larger.

An Example of a Badly Encrusted Pipe Line

This type machine is of flexible design fitted with pressure diaphragms and four or more rings of cutters for removing the incrustation. Such machines are capable of going through valves and bends up to 45 deg. angle in 6 to 12-in. pipe and for pipe lines in excess of 12 in. will pass through a 90-deg. bend.

In operation a fitting or section of the pipe to be cleaned is removed ahead of the pressure pump or other source of supply, the machine inserted and the line restored. At the end of the line or section to be cleaned a fitting or section of pipe is removed to provide for a free outlet of water and incrustation.

The pump, or pressure from other source, is then applied behind the machine forcing it ahead through the pipe line. As it moves forward, the incrustation is washed ahead and out the open pipe end. The movement and travel of the machine can be detected and followed by walking along the ground surface above the line.

The water pressure required for the machine varies with the size of the line, ranging from 65 to 100 lb. with flows of 300 to 700 g.p.g. to wash the line ahead of the machine.

This type equipment is usually rented on a foot basis for the size pipe to be cleaned and can be obtained with or without an attendant.

The length of line to be cleaned on one run depends on the thickness of the deposit.

Chemical Method

The chemical method is usually limited to the same extent as in the case of sewer lines, being used principally for small size pipe, bends, fittings, pipe lines not readily accessible, and where mechanical means are impracticable. Cleaning is generally accom-

The Same Pipe After It Had Been Cleaned

plished by means of inhibited hydrochloric acid, the addition of the inhibitor preventing attack on ferrous metal.

The cost of acid cleaning has been found relatively high. Aside from the cost itself, the disposal of partially active liquid waste into open channels or sewers should receive careful consideration beforehand. It has not been found practicable to completely neutralize acid action in the cleaning process, and this may lead to complications or extra costs in disposing of the liquid waste in a safe manner.

Commercial inhibited hydrochloric acid is usually of 28 percent strength. It has been used with good results when diluted with water to about 8 percent, this strength being recommended so as to prevent violent reaction and the rapid formation of gas with its attending difficulties of control.

The procedure consists of completely isolating the section of pipe line to be cleaned. A storage tank for the acid solution, of ample capacity (of from 3 to 4 times the displacement of pipe section to be cleaned) usually of steel or similar metal, is set near one end of the pipe line under consideration.

From a point near the bottom of this storage tank, a pipe line is installed to the suction side of a pump, either hand or power operated. The discharge from the pump is connected to the far end of the section of pipe, to be cleaned, and, from the near end of this pipe section, a return pipe for the acid solution is installed, ending in a tee with open-end pipe runs attached thereto—one vertically downward into the storage tank, and one vertically upward, the latter acting as a relief vent for gases formed in the

cleaning operations. An additional valved return outlet is provided so as to permit wasting the returned liquid. This is desirable for the reason that, upon starting the pump, the initially returned liquid has no acid properties, and until active liquid appears, it should be prevented from reaching the acid storage tank, where it would not only dilute the acid, but take up valuable storage space as well.

Frequent checks are made of the acid strength of the circulating solution. If a decrease is noted, fresh acid is added to the storage tank. When the strength no longer decreases, little, if any, further cleaning action may be expected, and circulation can be discontinued. Fresh water, forced through the pipe line exhausts the solution still remaining in the pipe line, until all acid has been displaced.

Upon completion of the cleaning operations, any active solution may be recovered for further use. Usually it is found more economical to waste it, selecting a location where that can be accomplished without detrimental effects.

Results and Conclusions

Results are given only for pipe lines other than sewer lines for the reason that, unless a sewer becomes wholly or partially inoperative, no effort is necessary from the standpoint of economy to incur any expenditure for cleaning it.

There is a decided economy, however, in maintaining in a proper state of efficiency pipe lines conveying water.

Pumping plants may be overtaxed, and delivery of water to important points of use may be slowed down so as to seriously affect the economy of operation and safety.

The costs for operating pumps vary closely in proportion to the time required for delivering a given volume of water. Any increase in flow capacity of a pipe line is therefore a measure of economy. Frequently increased flow capacity by reason of cleaning has been attended by an appreciable lowering of pump pressures, and with it, less power consumption as an added saving.

In supply lines under static pressure, the chief benefits derived from cleaning consist in eliminating delays in watering locomotives, speeding up operations in general, where water is a factor, and, in some cases, the reduction in fire hazard. Some of these benefits may be reduced to a definite money saving.

Considerable and definite benefits and economies have been secured by cleaning pipe lines as evidenced by results secured, a few of which are given here, as representative:

	Pipe Line		*G.P.M.*	
	Diameter Inches	*Length Feet*	*Before Cleaning*	*After Cleaning*
Water Column Supply	12	525	380	2,000
Water Column Supply	12	517	864	1,793
Pump Discharge	10	17,268	450	633.5
Fire Line	6	925	260	396
Fire Line	4	1,732	50	250

Reference is made to the previous report on this subject presented by your committee in the AREA Proceedings for 1921, Vol. 22, pages 413 to 418 and 421 to 426.

Report on Assignment 9

Practicable Size of Water Columns and Supply Lines for Maximum Delivery of Water to Locomotive Tenders

H. E. Silcox (chairman, subcommittee), C. B. Bryant, R. W. Chorley, R. E. Coughlan, P. W. Elmore, R. N. Foster, E. M. Grime, J. P. Hanley, R. L. Holmes, A. W. Johnson, J. J. Laudig, W. A. McGee, Theodore Morris, O. T. Rees, R. M. Stimmel, J. E. Tiedt, H. W. Van Hovenberg, R. E. Wachter, K. J. Weir.

Your committee submits the following report as information.

On American railroads the fast passenger and freight train schedules of today are being achieved by increased speed, lengthening of runs between water stops and by reducing the time required for such stops. With changing conditions, in the past few years the problem of water delivery to locomotive tenders has become extremely important and in many cases improvements have been inaugurated to reduce the time required to provide water at terminals and intermediate watering points.

With the increased demands, tender capacities of 7,000 to 12,000 gal. and delivery rates of 1,500 gal. per min. are no longer considered satisfactory. The changed requirement is being met with tenders of 24,000 gal. capacity and water delivery rates of 3,500 to 5,500 gal. On many railroads the limitations of small capacity tenders have been reduced by the addition of a water tank car.

The delivery of a water column is contingent on the following factors:

(a) Size, length and condition of supply pipe line
(b) Flow head of storage tank above the water column outlet
(c) Size of storage tank
(d) Type and design of water column

As an illustration of the delivery of water, the flow head as shown on hydraulic charts indicates the friction loss in a 16-in. supply line is one-tenth of that in an equivalent length of 10-in. pipe.

The use of storage tanks with as large a capacity per foot of height as practical should be considered in order to retain as high a flow head as possible, thus maintaining the maximum uniform delivery rate, as the lowering of the flow head brings about a further reduction in delivery.

To obtain representative data covering present and proposed methods, a questionnaire was submitted to 32 railroads, and an analysis of the replies indicates that the railroads have given scant attention to the selection of the type and design of water columns and the size of supply lines. The following is a summary of general operating conditions:

Average flow head above water column outlet	25 ft.
Maximum flow head above water column outlet	
Using storage tank supply	104 ft.
Using city water main supply	231 ft.
Average water column delivery	2,500 g.p.m.
Maximum water column delivery	5,500 g.p.m.
Locomotive tender capacities	14,000 to 25,000 gal.

The most common source of water supply for columns is the storage tank with suitable delivery lines to provide for a maximum discharge with the available flow head.

In other cases connections are made to city water mains (which are permitted by only a few municipalities) or large capacity electric pumps with control equipment are installed to deliver water from the source of supply directly to the column.

Many supply systems are such that it is impractical to increase the flow head on the water column or increase the size of the line to secure a higher rate of delivery. In such cases the delivery can be increased as much as 150 percent by the installation of a loop or dual supply line, or by installing a storage tank near the point of delivery.

In the older supply systems the water delivery often falls off due to incrustation in the pipe line and water column. Cleaning by machine or other means has in many cases increased the delivery from 90 to 125 percent and restored the line to practically its original carrying capacity.

Another method of increasing the supply line delivery in cases involving a low flow head, is to install a large capacity electric motor driven booster pump in the line, which will start automatically when the water column valve is opened. Such an installation would be very expensive to install and operate, and only one has been reported as being used. In new or reconstructed installations, the storage tank or tanks should be so located as to provide for the shortest possible water column supply line.

Under present operating conditions, it is necessary to deliver water to locomotive tenders with cistern openings that are from 9 ft. 6 in. to 13 ft. 6 in. above the top of rail. In order to cover this range, the modern water columns are equipped with curved goose neck outlets and telescopic spouts. With the introduction of excessively high water delivery and the varied angle of the spout the force of the water has a tendency to kick the spout out of the cistern opening, thus presenting an appreciable hazard in handling the watering operation. This type of installation with high delivery rate cannot be used with safety on the lower tenders. Some roads use chains or a special locking device for holding the spout in place. Observation indicates the use of these anchoring devices consumes time and causes delay to the watering operation.

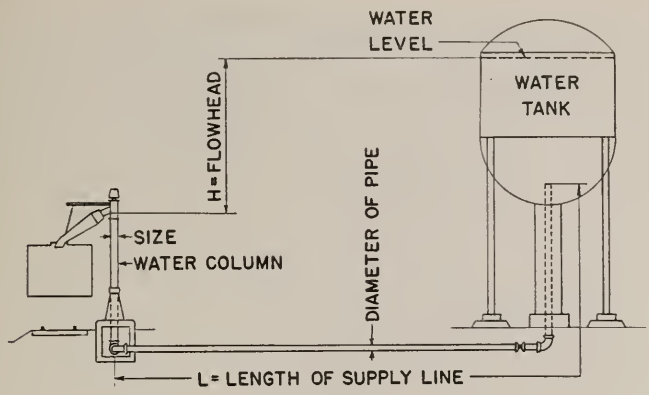
With higher rates of water delivery, it is essential that the tender be vented by opening additional covers to prevent surging, wetting the fireman, and allowing for rapid release of entrapped air. The outlet end of the spout should be of ample size to provide a free water outlet and thus avoid backlashing. In a number of cases with high velocity flows, the bucking of the column spout is so great that throttling of the supply line valve is necessary to maintain a safe watering operation.

With the faster rates of water column delivery and sudden stoppage of flow with valve closures ranging from 6 to 10 sec., it is important that the column and supply line be equipped with an adequate slow closing device or relief valves to prevent water hammer damage to the pipe line.

The recommended safe maximum water column deliveries of the various railroads range from 3,000 to 5,500 gal. per min. However, with the use of improved type equipment, it is believed 3,500 to 5,500 gal. per min. is the practical maximum safe limit, depending on uniformity in height of locomotive tenders to be watered.

In the selection of water column and supply line sizes, no fixed rule can be set as there are too many variable conditions in the individual locations. Each case should be given separate study to obtain the desired results in the most economical manner.

A diagram and six graphic water column delivery charts have been prepared as a guide in selecting a column and supply line to provide the desired water delivery under various flow head conditions, and are made a part of this report. The charts show delivery in gallons per minute for supply lines from 100 to 3,000 ft. in length with the following combinations:



NOTES

GRAPHIC DELIVERY CHARTS BASED ON ALLOWANCE
FOR THE FOLLOWING FACTORS
H = FLOWHEAD IN FEET.
L = LENGTH OF SUPPLY LINE.
ENTRANCE HEAD LOSS
FRICTION LOSS OF 3 ELBOWS
FRICTION LOSS OF 2 GATE VALVES
FRICTION LOSS OF 1 REDUCER AS REQUIRED
FRICTION LOSS OF SUPPLY LINE
HEAD LOSS OF WATER COLUMN
VELOCITY HEAD LOSS

Fig. 1.—Water Column Delivery Charts—Explanation.

(1) 10 inch water column and 12 inch supply line.
(2) 10 " " " " 14 " " "
(3) 10 " " " " 16 " " "
(4) 12 " " " " 12 " " "
(5) 12 " " " " 14 " " "
(6) 12 " " " " 16 " " "

These charts take into consideration all of the hydraulic factors which enter into the functioning of a water column delivery system. Water deliveries shown in gallons per minute have been checked with actual performance.

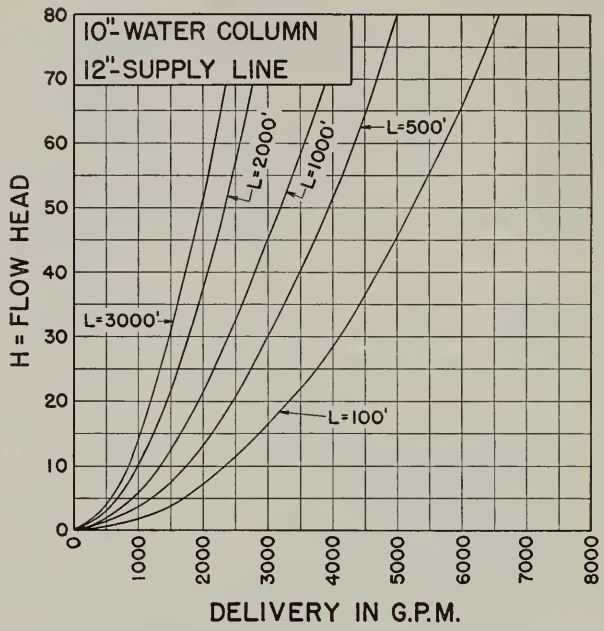
In addition to their value in planning new work the charts will be of assistance in checking the performance of existing installations, as periodic delivery checks compared with the graphs will disclose pipe line restrictions and other factors requiring attention to maintain full efficiency of the facility.

Conclusions

The delivery of water columns can be increased in several ways:

(a) Cleaning existing supply lines.
(b) By installation of auxiliary supply line forming a loop system.

(text continued on page 105)



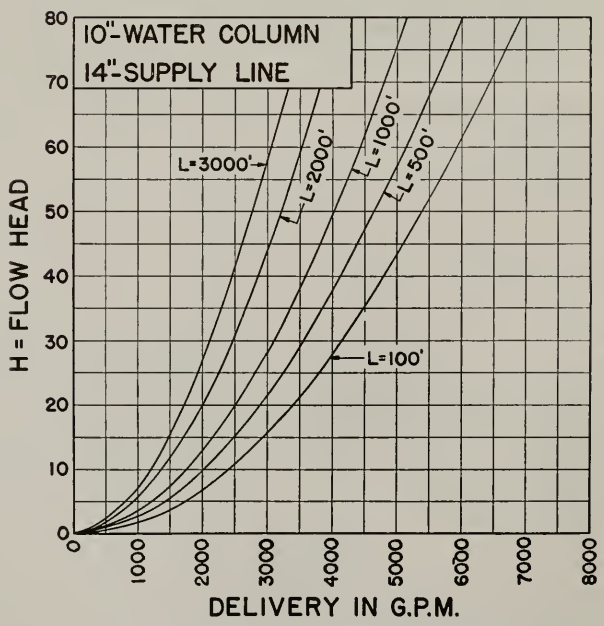
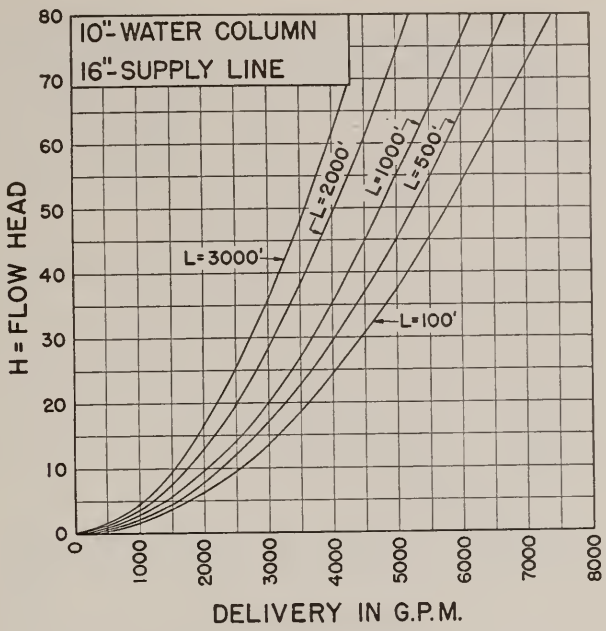


Fig. 2.—Water Column Delivery Charts.



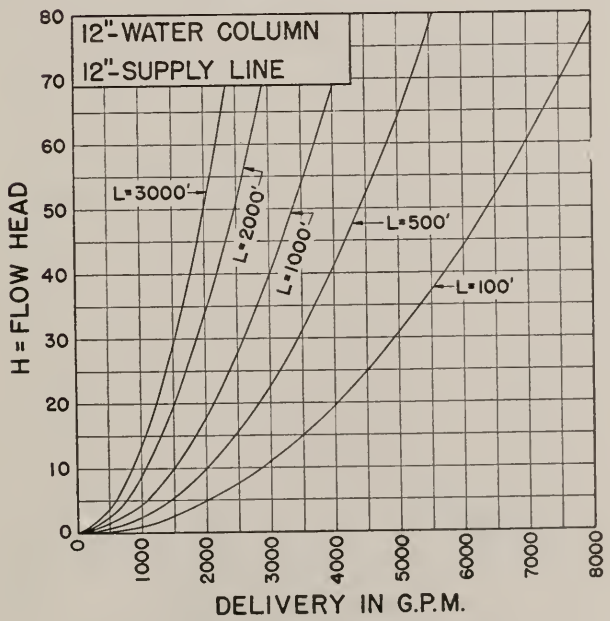
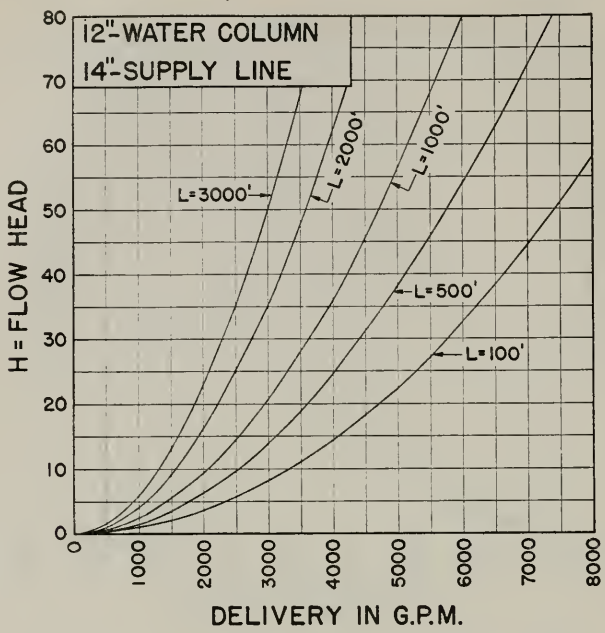


Fig. 3.—Water Column Delivery Charts.



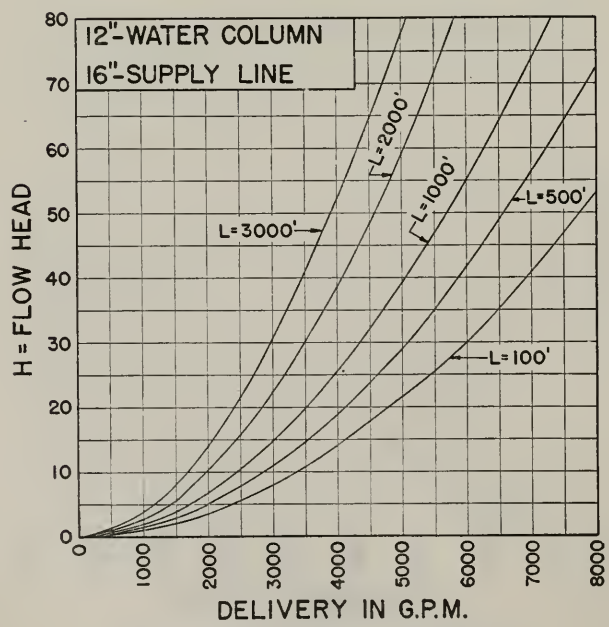


Fig. 4.—Water Column Delivery Charts.

(text continued from page 101)

(c) Increase size of supply line serving the water column.

(d) Locate the storage tank as close to the water column as possible.

(e) The use of larger size water columns is not a major solution of the higher delivery problem, as consideration should also be given to the size of supply line, its length and the flow head.

(f) Use of improved type water column with telescopic spout.

Recommendations

1. Make a separate study of each location to obtain the desired results in the most economical manner.

2. The size of the water column supply line should be governed by the available flow head and delivery desired.

3. The maximum safe delivery from special water columns of improved types serving locomotive tenders of uniform height is considered to be 5,000 to 5,500 gal. per min., as higher rates of flow will increase the time of taking water because the flow will be tapered off for the last 2,000 or 3,000 gal. to prevent overflowing locomotive tender, and time will be lost in handling the anchoring devices which would be necessary.

4. The maximum safe delivery of improved type water columns serving variable height locomotive tenders without special anchoring devices is considered to be 3,500 to 4,500 gal. per min.

5. Standardize on type of water column to minimize the stock of repair parts required for maintenance and emergency replacements.

Report of Committee 20—Uniform General Contract Forms

W. G. Nusz, *Chairman,*
E. H. Barnhart
Clark Dillenbeck
W. D. Faucette
J. P. Hanley
B. Herman
N. D. Hyde
F. R. Layng
S. L. Mapes
A. A. Miller
O. K. Morgan
F. L. Nicholson
C. B. Niehaus
J. S. Lillie, *Vice-Chairman,*
H. A. Palmer
W. M. Post
Huntington Smith
W. R. Swatosh
E. L. Taylor
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report submitting Form of Agreement for the Purchase of Electrical Energy for Other Than Traction Purposes, which is presented as information below.

2. Suggestions for use in preparing a lease for air right development.

   Final report presented as information.....page 113

3. Form of agreement for wire or cable line crossings, collaborating with Committee 3—Overhead Transmission Line and Catenary Construction, Electrical Section, Engineering Division, AAR.

   Final report presented for adoption and publication in the Manual.....page 115

4. Form of agreement for advertising signs on railways, including signs in coaches.

   No report.

The Committee on Uniform General Contract Forms,
W. G. Nusz, *Chairman.*

Report on Assignment 1

Revision of Manual

W. R. Swatosh, (chairman, subcommittee), W. D. Faucette, J. S. Lillie, A. A. Miller, F. L. Nicholson, W. M. Post, E. L. Taylor.

A report on the proposed revision of the Form of Agreement for Wire or Cable Line Crossings is presented under Assignment 3 which has been the responsibility of a special committee.

At the request of the Electrical Section, Engineering Division, AAR, this subcommittee has been collaborating with Committee 1—Power Supply of that Section, in a revision of the Form of Agreement for the Purchase of Electrical Energy for Other Than Traction Purposes (Manual page 20–101). A form is submitted herewith which, if later adopted, will replace the form now in the Manual. This form is submitted as information and will be further studied next year.

FORM OF AGREEMENT FOR PURCHASE OF ELECTRICAL ENERGY FOR OTHER THAN TRACTION PURPOSES

THIS AGREEMENT, made this.....day of..... 19...., by and between....., a corporation organized and existing under the laws of the State (or Commonwealth) of....., hereinafter called the Railway Company, and....., a corporation organized and existing under the laws of the State (or Commonwealth) of....., hereinafter called the Electric Company.

WITNESSETH:

That, in consideration of the covenants and agreements hereinafter contained, the expected performance thereof, the electrical energy to be delivered, the sums of money to be paid and other considerations, it is mutually agreed as follows:

1. Form of Energy

The electrical energy to be supplied under this agreement shall be in the form of .....phase alternating current of.....cycles and.....volts, and shall be measured on the.....side of the.....Company's transformers; or direct current of.....volts.

2. Point of Delivery

The electrical energy furnished hereunder shall be delivered at a point (or points) on the Railway Company's property to be mutually agreed upon and hereinafter referred to as the "Delivery Point."

3. Limits of Fluctuation

The Electric Company agrees, subject to the ordinary fluctuations incidental to the usual practice in generation and transmission of electrical energy, that it will maintain uniform frequency and voltage at the delivery point. Under normal operating conditions the permissible degree of variation of frequency for alternating current of..... cycles shall be.....cycles above or below normal, and for alternating or direct current of.....volts the permissible degree of variation shall be.....volts above or below normal.

4. Character of Load

The Railway Company shall have the right to use the electrical energy furnished hereunder for its power and lighting requirements and for any other purposes mutually agreed upon incidental to the operation of its railroad and its allied interests.

5. Capacity

The Electric Company agrees to have available at all times a capacity of equipment sufficient to furnish continuous supply of electrical energy up to the limit of the prevailing maximum demand of the Railway Company.

6. Rates

The Railway Company agrees to pay monthly to the Electric Company upon rendition of bills for electric service rendered hereunder, an amount based on the Power Company's rate schedule.....(See note)

(If suitable rates are not established, the following form of Rate Schedule is suggested:)

(a) Demand Charge: A demand charge of.....dollars per month per kw (or kv.a.) of maximum demand as determined in Paragraph "d" hereunder. (The demand charge may also be set up on a sliding scale schedule if found more desirable.)

(b) Energy Charge: In addition to the demand charge, energy charge of..... mills per kw.h. (The energy charge may also be set up on a sliding scale if found more desirable.)

(c) Discounts: Bills shall be payable by the Railway Company monthly for service rendered hereunder and shall be subject to a prompt payment discount of..... percent if paid within.....days after the date of bill, and any other discounts which may be provided.

(d) Contract kw. (or kv.a.): The contract kw. (or kv.a.) under this schedule shall be the.....-minutes demand of the combined lighting and power load determined by suitable demand meters. The average of the three highest demands so established (no two of which shall be on the same calendar day and measured during a month) shall be used as the billing maximum demand for that month. The minimum demand for which the Railway Company shall pay under this schedule shall be .....kw. (or kv.a.).

(e) Power Factor: (If demand charge is based on kv.a. of maximum demand, no power factor clause is necessary. If on a kw. basis, the following clause may be included: The Railway Company agrees to maintain at all times a power factor of not less than .....percent.)

(f) Change in Energy Charge Due to Fuel Cost: It is further agreed that the prices to be paid to the Electric Company for electrical energy consumed by the Railway Company are based upon cost of.....cents per.....B.t.u. of fuel delivered f.o.b. alongside generating station. If at any time during the continuance of this agreement the cost of fuel as aforesaid is increased or decreased, the Railway Company shall pay to the Electric Company, after such increase or decrease, an additional or lesser amount for the electrical energy consumed hereunder equal to.....mills per kw.h. for each.....cents of such increased or decreased fuel cost.

7. Supplying Electrical Energy to Any Consumer

In the event the Electric Company supplies electrical energy to any consumer under conditions substantially similar to and at rates lower than those herein provided, the Electric Company agrees to charge the Railway Company such lower rates in lieu of the rates provided for herein.

8. Prevention of Use

In the event the Railway Company is prevented at any time, by reason of strike, riot, insurrection, civil or military authority, fire, explosion, act of God, or any other cause beyond its control, from making use of the electrical energy to be supplied hereunder in whole or in part, or the Electric Company is unable to supply such electrical energy, then the minimum demand charge to the Railway Company shall be reduced in proportion to the inability of the parties to perform their respective obligations hereunder.

During the time or times when because of strikes, floods, fires, destruction of property, unavoidable accident, or from other cause beyond the control of the obligated party, the Electric Company shall be unable to make delivery of electric power or energy to the Railway Company, or the Railway Company shall be unable to use power or

energy furnished by the Electric Company, as hereinbefore agreed, the Railway Company may procure any electric power or energy required to maintain its electrical operations from other parties than the Electric Company.

9. Meters

All meters shall be furnished and maintained by the Electric Company and shall be tested by approved methods by the Electric Company at its own expense during the months of.....and.....and the Electric Company shall, where necessary, adjust or replace defective meters. The Electric Company shall give to the Railway Company at least.....days' notice when each test is to be made and representatives of both parties shall be present thereat. If, upon test, a meter is found to be inaccurate, it shall be promptly restored to an accurate condition or a new meter shall be substituted; should any meter be found to register in excess of.....percent, either above or below normal, the correction in the readings of such meter shall be made for one-half of the inaccuracy found, provided the error is less than ten percent, and if the error is more than ten percent, the electrical energy consumed shall be estimated by agreement between the parties, but no such correction shall be made in excess of thirty days prior to the date of the test and in no case prior to the date of the last prior test. (See Note 2)

10. Rules and Regulations

(a) Terminal Facilities: The Electric Company shall at its own cost and expense extend its service line to the terminal or delivery points established as hereinbefore provided for delivery of power hereunder and for this purpose the Railway Company shall provide the right of way on, over or under its premises necessary for service line in reaching said delivery points.

It is agreed that no service line or electrical apparatus of the Electric Company installed under this agreement and located on, over or under the property of the Railway Company, shall be used by or for any person, firm or corporation other than the Railway Company except with the permission of the Railway Company given in writing and specifying the authorized additional use or construction facilities.

(b) Company Installation: All apparatus and appliances necessary to make and maintain proper connections to the circuits of the Railway Company at the delivery points designated shall be provided, maintained and kept in repair by the Electric Company. All apparatus and appliances thus provided by the Electric Company shall remain the property of the Electric Company and change thereof may be effected at its option, except that the type of demand meter shall not be changed other than by mutual agreement. The Railway Company shall not do any work upon any apparatus or meter belonging to the Electric Company.

The Electric Company shall install and maintain its meters in such manner that authorized representatives of the Railway Company may read them at such time as may be desirable.

11. Liability

The Railway Company agrees to indemnify and save harmless the Electric Company from all cost, expense or liability for damages, which may arise or result from the use, care or handling of the energy delivered hereunder after the same shall have been delivered to the Railway Company at the points of delivery specified herein, or from the presence upon the premises of the Railway Company of any appliances of the Electric Company, except that the Electric Company shall be responsible for all claims of its own employees, agents or servants.

The Electric Company agrees to indemnify and save harmless the Railway Company from all cost, expense or liability for damages which may arise or result from the use, care or handling of the energy delivered hereunder before the same shall have been delivered to the Railway Company at the points of delivery specified herein, or from the presence upon the premises of the Electric Company of any appliances of the Railway Company, except that the Railway Company shall be responsible for all claims of its own employees, agents or servants.

12. Interference With Apparatus

The Railway Company shall use reasonable care to prevent anyone other than the authorized employees of the Electric Company from interfering with meters or other appliances of the Electric Company.

13. Arbitration

In case any question arises under this agreement or concerning the subject-matter thereof, upon which the parties hereto cannot agree, such question shall be settled by a sole, disinterested arbitrator, to be selected jointly by the parties to this agreement, and if they fail to select such arbitrator within.....days after demand for arbitration is made by either party hereto, then such arbitrator shall be appointed by the judge of the.....court of.....

The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as determined by the arbitrator.

14. Access to Premises

The Electric Company shall have the right of access to the premises of the Railway Company at all reasonable times during the period of this agreement for the purpose of reading meters and inspecting and repairing the Electric Company's equipment, and, on the termination of this agreement, for the purpose of removing its property.

15. Termination of Agreement as Applied to Any Point of Service by Loss of the Railway Company's Plant

In event of the loss or destruction of the Railway Company's plant at any point of service, the Railway Company may, upon written notice to the Electric Company, terminate this agreement with respect to such service as such loss or destruction renders useless to the Railway Company.

16. Regulation by Public Utility Regulatory Bodies

The rate, rules and regulations under which said electric service is furnished hereunder are subject to revision to conform to such changes as may be lawfully prescribed by the..... In the event that the rate is revised and that the revised rate is not acceptable to the Railway Company, the Railway Company shall have the right to terminate this agreement on.....days' written notice to the Electric Company.

The Electric Company shall notify the Railway Company in writing of any contemplated change in the rates hereunder at least thirty days prior to any notice to the regulatory body having jurisdiction.

17. Term

This agreement shall take effect as of the.....day of.....19...., and shall continue until the.....day of.....19...., and thereafter until terminated by written notice given by either party to the other at least..... days prior to the date of termination.

18. Successors

This agreement and each provision herein contained is hereby made binding upon the legal representatives, successors and assigns of each party hereto.

In Witness Whereof, the parties hereto have executed this agreement in..... ....., the day and year first above written.

Witness..... .....Company

By.....

Witness..... .....Company

By.....

Note: (1) When selecting rate schedule the following points should be given consideration:

(a) If the rate schedule provides for billed demand either on a yearly or a monthly basis, check to determine which would probably be more favorable.

(b) Check to determine whether the rate schedule is such that a high demand established in one month is billed for succeeding months.

(c) Check to determine whether the rate schedules have any special provisions, such as per diem demand charge, to enable the customer to reduce his bill and not be unduly penalized for a high demand established accidentally during one month.

(d) Check the rate schedules to determine whether the demand interval is five, fifteen, or thirty minutes, or longer. Select as long a demand interval as possible.

As an alternate to continuous use of a demand meter the demand may be determined and agreed upon based upon connected load or other acceptable method.

(e) Check to determine whether it is economical and practicable to shut down any of the equipment during the period when the peak demand will occur. If so, it may be possible to apply an automatic demand limitator to one or more machines.

(f) Check to determine whether a penalty is imposed for a low power factor or a bonus offered for a high power factor, and if so, whether or not corrective equipment or synchronous meter drive can be economically applied.

(g) Check to determine if Night Rider is applicable, as certain work might be changed to night or off-peak operation to reduce energy cost or billing demand.

(2) If there is no regulatory body having jurisdiction over the accuracy of the meters, a maximum variation of one percent above or below should be agreed upon.

Report on Assignment 2

Suggestions For Use in Preparing a Lease For Air Right Development

J. S. Lillie (chairman, subcommittee), E. H. Barnhart, Clark Dillenbeck, J. P. Hanley, B. Herman, N. D. Hyde, F. R. Layng, S. L. Mapes, O. K. Morgan, C. B. Niehaus, H. A. Palmer, W. M. Post, E. L. Taylor.

This report is submitted as information with the recommendation that the subject be dropped.

The problems of a long term lease for air right development are similar to problems on all long term leases, wherein probable change of the surrounding conditions of the property, changes of personnel, and changes of value of land and structures are almost certain to take place, and should be properly provided for in the terms of the lease. It is highly essential that an adequate rental be reserved to the owner and it is just as essential that the rental not be excessive or it will tend to failure of the project through default of the lessee. It is important from the railroad's standpoint to assure itself of the responsibility of the lessee and completion of the project as otherwise the railroad's property is encumbered with a partially completed building which must either be removed or completed at considerable expense in either case.

At the present time air rights developments exist principally in New York City, Chicago and Cleveland and attention is called to the list of documents available in studying this subject, which appear at the end of the report on this assignment.

Conditions vary in the field of this Association to such an extent that it is impossible to draft a long term air right lease which could be used without change in any part of the United States. For that reason, and to assist those engineers seeking information on this subject, they are referred to "Problems of Long Term Leases", published by the University of Michigan, School of Business Administration. A summary of the conclusions is as follows:

1. The chief points of difficulty that arise in connection with the long-term lease are (a) fixing the rent, (b) establishing security for the lessor, (c) termination provisions, and (d) condemnation provisions.

2. A flat rental based upon a fair rate of return upon the value of the land at the time the lease was written represents a payment which is fair to both the lessor and the lessee. The rent thus established may be paid at such times and in such amounts as best suit the convenience of both parties to the lease.

3. Step-up or step-down rentals are properly used only to arrange, to suit the convenience of the parties, the date and amounts in which the rent is to be paid.

4. Reappraisal leases represent a method of fixing rents which is theoretically fair to both parties, but which in practice proves difficult of operation except in eastern cities where the length of the term between reappraisals is usually 21 years.

5. The most common type of security provided for the payment of rents is the erection of a building by the lessee; a deposit of cash or liquid securities protects the lessor during the period of the erection of the structure; a cash payment for buildings already on the property is considered as security when the buildings are available for use by the lessee.

6. (a) It is recommended that some provision be made to give the lessor security as any structure built or to be built on the property becomes obsolete.

(b) With respect to taxes, it should be provided that the lessee should pay all taxes levied and assessed due to the air rights lease and also any increase in taxes levied against the lessor on its property under the air rights lease. It should also be provided that in states where an income tax might be levied against the lessee or a leasehold tax might be levied on the improvements erected under the air rights lease that all such charges should be assumed by the lessee or, if paid in the first instance by the lessor, that they should be promptly re-paid within 30 days after receipt of bills therefor.

7. Termination provisions which grant the building free to the lessor at the end of the term have some objectionable features. These may be met by providing that the lessor shall either purchase the building at its appraised value at the time of termination, or allow the lessee to purchase the land at a specified price. When neither party takes advantage of the opportunity thus provided, it is suggested that the parties become tenants-in-common, sharing the property in the proportion which the appraised value of the land bears to the appraised value of the structure.

8. Three types of condemnation provisions are in common use. The first provides that the award in the case of condemnation shall be divided between the parties in the proportions which the appraised values of their respective estates bear to each other, or to the value of the property as a whole. The second type of provision provides that the lessor shall receive that portion of the award which is made on account of land value, and the lessee that portion awarded for building. The third type of condemnation provision grants to the lessor the capitalized value of the rentals reserved, the balance going to the lessee.

9. The condemnation clause which provides that the award shall be distributed to the parties in proportion to the appraised value of their respective interests is recommended.

10. Practices in connection with the writing of long-term leases vary between different sections of the country but are fairly uniform within the same section.

Leases and Documents Available for Study in Preparation of Form of Lease of Air Rights

1. Problems of Long Term Lease—University of Michigan.

2. Subdividing the Air—Herbert Becker, vice president, Chicago Title & Trust Company.

3. Air Rights and The Chicago Daily News—Walter A. Strong, publisher of Chicago Daily News.

4. 99-Year Lease—August 1, 1927—Chicago Union Station Company to Chicago Daily News Printing Company.

5. Warranty Deed—Chicago Union Station Company; Pittsburgh, Fort Wayne & Chicago Railway; The Pittsburgh, Cincinnati, Chicago & St. Louis Railroad; The Pennsylvania Railroad; Chicago, Milwaukee & St. Paul Railway, H. E. Byram, Mark W. Potter and Edward J. Brundage, receivers, and Herbert A. Lundahl, special master, to Chicago Daily News Printing Company.

6. General Warranty Deed—From Chicago & Northwestern Railway to Marshall Field & Co. Portions of Wells Street property.

7. Lease—W. M. Brown to Cleveland Athletic Club. April 28, 1910.

8. Lease—Long Island Railroad and Postal Service Building Corporation.

9. Lease—Cleveland, Cincinnati, Chicago & St. Louis Railway and Covington & Cincinnati Elevated Railroad & Transfer & Bridge Company.

10. Lease—5–20–25—New York State Realty & Terminal Company with Barclay Park Corporation. New York City—Lexington Avenue. 2 Registry Numbers.

Report on Assignment 3

Form of Agreement for Wire or Cable Line Crossings

F. L. Nicholson (chairman, subcommittee), W. D. Faucette, S. L. Mapes, W. M. Post, W. R. Swatosh.

During the 1940 convention, this committee presented for such action as the convention desired to take, a form of agreement that had been prepared by a special committee of the Engineering Division, AAR, at the request of the Rural Electrification Administration, "to prepare a uniform contract and specifications governing wire crossings as a basis of meeting the requirements of the Rural Electrification Administration, which will be satisfactory to the railroads generally". This assignment, made November 11, 1938, and diligently worked on until October 1939 when the tentative report was filed for the 1940 convention,—it was then stated that the form was not complete as it had not been approved either by the Rural Electrification Administration or by the Association of American Railroads, but because of the general interest and the number of inquiries as to progress, it was thought wise to adopt it as recommended practice for such use as the members desired to make of it. The committee continued its negotiations with the REA committee in an effort to reconcile the differences in view point then prevailing, believing that a form of agreement reasonably satisfactory to both parties would be very advantageous. These discussions have resulted in certain changes in the form as presented, which we believe better protect the interests of both parties and now meets with the approval of the Special Committee, the General Committee of the Engineering Division, AAR, Committee 20 of the AREA, and is acceptable to the Rural Electrification Administration.

Slight changes have been made in data sheet, Exhibit "A" which is intended as an application form, showing minimum information requirements to enable the railway to accept or reject the proposal when submitted by applicant, the railway may require additional information before approval if so minded. This form is not intended to be a specification as referred to in the assignment. The specifications for wire crossings referred to in the assignment are being prepared by a committee of electrical representatives of the Special Committee, and when completed, will probably be printed in the Manual of the Electrical Section. Reference to the specifications to be used is in Section 2 of the agreement.

The Form of Agreement and Exhibit "A", Application Data, are now completed and your committee recommends:

1. That the Form of Agreement, together with Exhibit "A", herewith submitted be accepted as recommended practice and printed in the Manual.
2. That the Form of Agreement for Wire or Cable Line Crossings, together with Exhibit "A", adopted 1940 and now in the Manual, pp. 20–112.1 thru 112.5, in conflict therewith, be withdrawn from the Manual.
3. That the Form of Agreement for Wire Line Crossings adopted 1936, now in the Manual, pp. 20–113 thru 115, which was used as a basis for the new form now submitted and is now in conflict therewith, be withdrawn from the Manual.
4. That the word "Wires," in the title of agreement, "Form of License for *Wires,* Pipes, Conduits, Drains, Hopper Pits, and Other Structures on Railway Property", now in the Manual, p. 20–117, be deleted from the title of that form.

FORM OF AGREEMENT FOR WIRE OR CABLE LINE CROSSINGS

THIS AGREEMENT made this ..... day of ....., 19...., by and between ....., a corporation duly organized and existing under the laws of ....., hereinafter called the Railway Company, and ....., hereinafter called the Licensee.

WITNESSETH:

WHEREAS, the Licensee desires to construct, maintain and use wire or cable lines and appurtenances, hereinafter called construction, for transmission or distribution of electric energy over or under and across the property, tracks and wires of the Railway Company, and over or under and across such wires of any other party or parties as Railway Company has permitted to be placed upon its property, such construction to conform to the data shown on the application sheet, approved by the Railway Company, dated ....., attached hereto and designated as Exhibit "A". It is mutually agreed as follows:

1. Permit

The Railway Company hereby permits the Licensee to construct, maintain and use the construction over or under and across the property, tracks and wires of the Railway Company, and the wires of such other party or parties as the Railway Company has permitted, or has contracted to permit, to place wires on its property, upon the following terms and conditions:

2. Specifications

(a) The Licensee shall, at its sole expense, construct, and at all times maintain, the construction in accordance with the design indicated on the aforesaid approved application sheet, the latest requirements of the Specifications of the National Electrical Safety Code and all amendments thereto, the latest requirements of the Specifications for Electric Light, Power Supply and Trolley Wires Crossing Railways, as from time to time approved by the Association of American Railroads and printed in the Manual of its Electrical Section, Engineering Division, (should there be any conflict between said specifications, those approved by the Association of American Railroads, as aforesaid, shall govern), and the provisions of applicable statutes and orders, rules or regulations of any competent public authority.

(b) If, in any particular, either of said Specifications conflict with any statutes or with any orders, rules or regulations of any competent public authority having jurisdiction in the matter, then such statutes, orders, rules or regulations shall prevail, but in all remaining particulars said specifications shall govern.

3. Construction and Maintenance

(a) The Licensee, in constructing and maintaining the construction, shall exercise every reasonable precaution and use all diligence to avoid interference with the operation of trains and locomotives, or with the use and enjoyment by the Railway Company of its property. The Licensee shall, except in emergency, give not less than .....( ) days' written notice to ..... of the Railway Company, of the day and hour it proposes to construct, reconstruct or maintain the construction. In event the ..... of the Railway Company considers the time specified in such notice unsatisfactory or inconvenient he shall, within .....( ) days after receipt of such notice, notify the Licensee, in writ-

ing, to that effect and shall specify a time satisfactory or convenient to the Railway Company.

Should emergency work arise the Licensee shall make every effort to notify the Railway Company that such work is to be done.

(b) The Licensee, failing properly to maintain its construction, shall reimburse the Railway Company for any and all expense that may be incurred by the Railway Company in making such repairs to the facilities of the Licensee as may be immediately necessary for the safety of trains and property of the Railway Company. The Railway Company shall give prompt notice of the making of such repairs.

The Licensee agrees to pay to the Railway Company the cost of such repairs on or before the fifteenth day of the month next succeeding that in which a bill therefor is rendered.

4. Use

The Licensee shall use the said construction solely for the purpose of conveying electric energy at a potential not in excess of that shown on the approved application sheet attached hereto as Exhibit "A", and shall make no change in construction or potential without first securing the approval of the ..... of the Railway Company.

5. Protection of Circuits

The Licensee shall protect the power, telegraph, telephone, signal and other circuits on, over or under the property of the Railway Company from damage of any kind by or because of the construction, maintenance and use of said construction, and shall construct, maintain and use said construction in such a manner as will not damage or injuriously affect the use of power, telegraph, telephone, signal or other circuits of the Railway Company or circuits of other companies that may have under contract the right to maintain such circuits on the property of the Railway Company.

6. Liability and Risk

(a) The Licensee and the Railway Company agree that, except as provided in paragraph (b) of this section, all cost or expense resulting from any and all loss of life or property, or injury or damage to the person or property of any person, firm or corporation (including the parties hereto and their respective officers, agents and employees) and any and all claims, demands or actions for such loss, injury or damage, caused by or growing out of the presence or use, or the construction, maintenance, renewal, change, relocation, or removal of the construction attributable to the concurring negligence of both parties hereto, shall be borne by them equally; if, however, any such loss, injury or damage shall be attributable to the negligence of one of the parties hereto, whether solely or combined with the negligence of any other person or corporation not a party hereto, and without the concurring fault or negligence of the other party hereto, then such party hereto which by its fault or negligence caused or contributed thereto shall indemnify, protect and save harmless the other party hereto therefrom.

(b) The Licensee assumes all risk of loss or damage to Licensee's poles, wires and equipment, inclusive of free or unused materials, supplies and equipment, however caused, resulting directly or indirectly, by reason of the installation, maintenance, use, existence or removal of the construction, and hereby releases the Railway Company from any and all liability on account of such loss or damage, whether or not the negligence of the Railway Company contributed thereto in whole or in part.

7. Insurance

The Licensee shall carry, at all times, while this agreement is in effect, Public Liability Insurance covering bodily injury or death in limits of $25,000 for the injury or death of each person, and $50,000 for each accident; and Property Damage Liability Insurance in limits of $10,000 for each accident, and a total aggregate limit of $25,000 for the annual policy period.

A certificate of such insurance shall be filed with the Railway Company.

8. Changes or Relocation

The Licensee shall, at its sole expense, within .....( ) days after receipt of written notice from the Railway Company, make such changes in the construction, including relocation, as may be required by the Railway Company, if such changes or relocation shall, in the judgment of the Railway Company, be needed for the better development or use of the property of the Railway Company, or if such changes or relocation shall, in the judgment of the Railway Company, be needed to protect its requirements or contractual obligations, or if such change or relocation is required, directly or indirectly, by statute or by any order of any competent public authority having jurisdiction in the matter. Provided, however, that the term contractual obligation used in this paragraph shall not be construed as including obligations similar hereto, entered into subsequent to the date hereof.

9. Discontinuance

The Licensee shall, at its sole expense, upon termination of this agreement, the abandonment or discontinuance of use of the construction, promptly remove its property from the premises of the Railway Company and restore such premises, disturbed by the construction, to a condition satisfactory to the ..... of the Railway Company, and upon the completion of such work this agreement shall terminate.

10. Cost of Changes

The Licensee, failing to change or relocate the construction within .....( ) days after the expiration of notice given as provided in Section 8, or remove its property as provided in Section 9, the Railway Company may, without further notice, in case of abandonment remove, and in case of necessary alteration, change or relocate the construction and render bills for the cost of such removal, change or relocation, to the Licensee, which bills the Licensee agrees to pay on or before the fifteenth day of the month next succeeding that in which such bill is rendered.

11. Taxes

The Licensee shall pay all taxes assessed upon the construction, or on account of the existence of the construction, and shall indemnify the Railway Company from the payment of such taxes.

12. Failure to Exercise Rights Not to Constitute Waiver

The failure of the Railway Company to exercise its rights hereunder upon the failure of the Licensee to perform the covenants and conditions herein contained, shall not be construed as a waiver of the covenants or conditions herein contained, but only a waiver of the particular breach, and the Railway Company may, at any time thereafter, upon the failure of the Licensee to perform the covenants or conditions in this agreement on its part to be kept and performed, exercise rights as herein provided.

13. Execution Official Act Only

The individuals executing this agreement do so only in their official capacity and none of the covenants herein contained are to be held or construed as their individual acts, or acts for which they may be individually liable in any way.

No warranty of title to any property is given hereunder, and the permit herein given to the Licensee is subject to all encumbrances, conditions, reservations upon or under which the Railway Company holds its property.

14. Fees and Rentals

Unless the construction is wholly within the confines of a public highway (it being understood that the overhanging of one or more wires or crossarms on the property of the Railway Company off the highway shall not be considered as making the construction fall without the confines of a public highway), the Licensee shall pay to the Railway Company a fee of ..... Dollars ($) for expenses in connection with the preparation and execution of this agreement, and, in addition thereto, pay for the privileges herein granted and for inspection expenses, the sum of ..... Dollars ($).

14. Fees and Rentals (Alternate)

Unless the construction is wholly within the confines of a public highway (it being understood that the overhanging of one or more wires or crossarms on the property of the Railway Company off the highway shall not be considered as making the construction fall without the confines of a public highway), the Licensee shall pay to the Railway Company a fee of ..... Dollars ($) for expenses in connection with the preparation and execution of this agreement, and, in addition thereto, pay for the privileges herein granted and for inspection expenses, the sum of ..... Dollars ($) per annum; said annual charges to be payable in advance on date of this agreement and on each anniversary date thereof.

15. Cancellation

The permit herein given shall terminate upon the abandonment of railway operation and the sale or other disposition of the railway right of way, or may be revoked by the Railway Company upon thirty (30) days' written notice to the Licensee for any failure of the Licensee to comply with any of the terms, conditions or covenants of this agreement, or may be cancelled by the Licensee upon thirty (30) days' written notice to the Railway Company of such intention.

16. Successors

This agreement shall inure to the benefit of and be binding upon the parties hereto, their successors or assigns, provided that the Licensee shall not transfer, assign or permit the use of the permit hereby granted by any person or corporation without the consent and agreement, in writing, of the Railway Company being first obtained, unless such transfer, assignment, or permission is given by the Licensee in pursuance of the obligations incurred by it to the United States.

In Witness Whereof, the parties hereto have executed this agreement, in ....., the day and year first above written.

.....
(Railway Company)

By

.....

.....
(Licensee)

By

.....

Witness:

.....

Witness:

.....

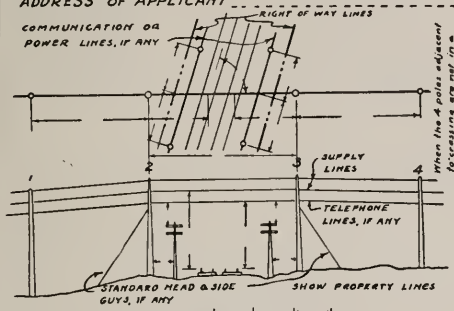
EXHIBIT "A"

DATA TO BE INCORPORATED
ON
PLANS PREPARED BY APPLICANT FOR WIRE OR CABLE LINE
CROSSINGS OVER PROPERTY OF THE RAILWAY COMPANY

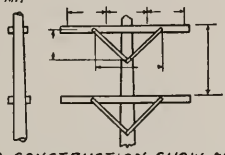
_____ 19__

NAME OF APPLICANT _____

ADDRESS OF APPLICANT _____



DOUBLE ARMS REQUIRED ON POLES 2 & 3



POLE TOP CONSTRUCTION SHOW AS ABOVE

DATA REQUIRED

Show Telephone Wire Attachments, if any

Size of arms _____ Material _____

Size & Type of Brace _____

Pin Spacing _____

Size & Type of Pins _____

Type of Arm Separator _____

Grounding Connection _____ Material ____ Size ____

Aerial Ground Wire _____ Material ____ Size ____

POLES	Height above ground	Dia. at Ground	Dia. at Top	ASA Class	Depth of Holes
No. 1					
No. 2					
No. 3					
No. 4					

Marking of Poles _____

Species of Timber _____

Size of Guy Wire _____ Material _____

Type of Guy Anchorage _____

Note:
Application to cross must be accompanied by copies of actual plans, to scale, showing location of crossing, poles, guys, existing lines, etc.

LOCATION DATA

Distance & direction of crossing from nearest Railway mile post, monument or center line of station _____

*Railway Operating Division _____

*Valuation Station _____

County _____ State _____

CROSSING DATA

Voltage _____ Frequency _____

A.C. or D.C. _____ No of circuits _____

WIRES- No. of _____ Size of _____

Material _____

Solid or stranded _____

Bare or insulated _____

Hard or medium hard drawn _____

SAG in WIRES _____

Design tension sag at Max. Load _____

Stringing sag _____

Sag under Max load _____

Ultimate unloaded sag _____

CLAMP or TIE _____

Type _____

INSULATOR- Type _____

Material _____

Maker & Cat. No. _____

GUY INSULATOR- Type _____

Material _____

Maker & Cat. No. _____

TELEPHONE LINE _____

Wire Material _____ Size _____

TEL. INSULATOR- Type _____

Material _____

Maker & Cat. No _____

APPLICANT _____

BY _____

TITLE _____

APPROVED AND ACCEPTED THIS _____ DAY OF _____ 19____

APPROVED _____

TITLE _____

*To be supplied by Railroad Company

Report of Committee 6—Buildings

L. H. Laffoley, *Chairman,*
C. M. Angel
G. A. Belden
C. E. Booth
E. Christiansen
H. M. Church
A. C. Copland
H. G. Dalton
A. G. Dorland
W. T. Dorrance
Hugo Filippi
J. P. Gallagher
W. G. Harding
A. T. Hawk
E. G. Hewson
C. D. Horton
N. D. Howard
A. C. Irwin
F. R. Judd
L. P. Kimball
H. C. Lorenz
E. K. Mentzer
A. B. Stone, *Vice-Chairman,*
H. A. Pasman
G. A. Rodman
C. H. Sandberg
C. P. Schantz
E. W. Scripture, Jr.
L. W. Smith
A. L. Sparks
S. G. Urban
O. G. Wilbur
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, including recommended revisions, presented below.

2. Preparation of specifications for railway buildings.
   Progress report, presented as information ..... page 127

3. Railroad warehouse requirements for handling quick frozen products.
   Final report, submitted as information ..... page 136

4. Refrigerator equipment for cold storage houses and rooms, collaborating with Committee 1—Power Supply, Electrical Section, Engineering Division, AAR
   No report.

5. Modernization of station buildings.
   No report.

6. Design of facilities and equipment for spray painting of rolling stock.
   No report.

The Committee on Buildings,
L. H. Laffoley, *Chairman.*

Report on Assignment 1

Revision of Manual

G. A. Belden (chairman, subcommittee), W. T. Dorrance, F. R. Judd, A. L. Sparks, S. G. Urban, O. G. Wilbur.

The committee recommends the following revisions of Section X, Specifications for Railway Buildings, Built-up Roofing, Manual pages 6–30; 6–32 and 6–33.

Page 6–30

2. Materials

Pitch.—Pitch for built-up roofs shall be the best quality, straight-run, American coal tar pitch, distilled direct from coal tar and free from water or ammonia.

For use on roofs having a slope not greater than 2 inches per foot, the pitch shall conform to Current ASTM Specifications D 450. Type A.

For use on roofs having slopes greater than 2 inches per foot, and not exceeding 6 inches per foot, the pitch shall conform to the current ASTM Specifications for Steep Roofing Pitch.

Asphalt.—Asphalt for built-up roofs shall conform to current ASTM Specifications for Asphalt for Use in Constructing Built-Up Roof Coverings, D 312.

Asphalt Primer.—Asphalt primer for use on concrete or gypsum decks shall conform to current ASTM Specifications D 41.

Roofing Felts.—Coal-tar saturated felt shall conform to current ASTM Specifications D 227.

Asphalt-saturated rag felt shall conform to current ASTM Specifications D 226.

Asphalt-saturated asbestos felt shall conform to current ASTM Specifications D 250.

Asphalt cap sheet for use in the construction of built-up roofs shall conform to current ASTM Specifications D 371.

Ready or Prepared Asphalt Roofing.—This type of roofing shall be delivered at the site in the original sealed packages of the manufacturer, and each package shall be properly wrapped and marked for ready identification.

Asphalt roofing surfaced with powdered talc or mica shall conform to current ASTM Specifications D 224.

Asphalt roofing surfaced with fine mineral granules shall conform to current ASTM Specifications D 248.

Asphalt roofing surfaced with coarse mineral granules shall conform to current ASTM Specifications D 249.

Flashing.—No change.

Gravel and Slag.—No change.

Page 6–32

Revise first sentence in first paragraph at top of page to read as follows:

Where felt flashings are called for, they shall consist of 3 layers of 14-pound asphalt felt and a cap flashing of mineral-surfaced roll roofing, conforming to current ASTM Specifications D 249.

Page 6–33

Revise first paragraph at top of page to read as follows:

Where felt flashings are called for, they shall consist of 3 layers of 14-pound asphalt felt and a cap flashing of mineral-surfaced roll roofing, conforming to current ASTM Specifications D 249.

The committee recommends that the following Specifications for Built-Up Roofing, Type A–3 and Type A–4, be adopted for publication in the Manual:

TYPE A–3

Tarred Rag Felt, Steep Roofing Pitch and Slag, for Use Over Wood or Precast Concrete or Gypsum Units

1942

(a) This type of roofing shall be limited to use on wood or precast gypsum decks having a slope more than 2 inches per foot, and not exceeding 6 inches per foot; or on precast concrete slabs having a slope of more than 1 inch per foot and not exceeding 6 inches per foot.

(b) This type of roofing shall be composed of 5 layers of not less than 14-pound tarred rag felt and a minimum of 130 pounds of steep roofing pitch and 250 pounds of roofing slag per 100 square feet.

(c) If on wood, lay one thickness of rosin-sized paper or unsaturated felt, weighing not less than 5 pounds per 108 square feet, over the entire surface, lapping the sheets at least 1 inch, and nailing them sufficiently to hold the sheets in place during application of the roofing; if on precast units, the sheathing paper shall be omitted.

(d) Over the entire surface, lay 5 plies of 14-pound tarred rag felt, at right angles to the incline of the roof, lapping each 26 inches over the preceding sheet for 32-inch wide felt, or 30 inches for 36-inch wide felt, with end laps of not less than 4 inches. Each sheet shall be nailed with 1-inch barbed roofing nails through flat tin discs, 8 inches from the upper edge of the sheets, and with nails not more than 1 foot apart. All 5 layers shall be turned up not less than 6 inches against vertical surfaces and fastened securely.

(e) Mop back on each sheet the full distance of the lap with steep roofing pitch. The felt shall follow and shall be embedded firmly in the hot moppings as applied. Care shall be taken that pitch moppings are even with the lower edge of each overlying sheet, and that the finished felt surface is clean and free from pitch drippings.

(f) Flashings shall be installed at the intersection of the roof with vertical surfaces, and the plans will show whether sheet metal of felt flashings are to be used.

Where metal flashings are called for, they shall be furnished and installed in accordance with Paragraph 1104, Section XI, Sheet Metal Work, and, in addition, the felt and pitch reinforcement shall be installed as follows:

After all plies of roofing have been laid, and before application of the slag, the contractor shall set in separately at the angles formed by the roof deck and vertical surfaces, 3 plies of 14-pound tarred felt, cemented together with steep roofing pitch. These plies shall extend out on the roof at least 4 inches, and up the vertical surfaces 6 inches. The last ply shall be coated with steep roofing pitch, and then the metal base and counter flashing installed as specified in Section XI. The flange of the base flashing on the roof shall be coated with hot steep roofing pitch, into which shall be bedded a 4-inch strip of felt, centered over the nailing course. This strip shall be coated with hot, steep roofing pitch, into which shall be bedded a second strip of felt 6 inches wide and completely covering the first.

Where felt flashings are called for, they shall consist of 3 layers of 14-pound asphalt felt and a cap flashing of mineral-surfaced roll roofing, conforming to current ASTM Specifications D 249. The felt strips shall be cemented to the roof and the vertical surfaces, and to each other, with an approved plastic roofing cement, reinforced with a mineral fibre.

The first strip of felt shall extend 6 inches up the vertical surface and 4 inches out on the roof; the second, 8 inches up the wall and 5 inches out on the roof; and the third, 10 inches up the wall and 6 inches out on the roof. Felt strips shall not exceed 10 feet in length, and shall be lapped at least 1 inch at all joints; all joints shall be broken. The cap flashing of mineral-surface roofing shall extend at least 4 inches in masonry walls and down to the roof deck, and shall be cemented to the base flashing with plastic roofing cement.

(g) Using a mop, a uniform coating of steep roofing pitch shall be spread over the entire surface of the roof, using not less than 50 nor more than 60 pounds of pitch per 100 square feet. Into this, while hot, embed 250 pounds of roofing slag per 100 square feet. In cold weather, the slag shall be heated before being applied.

Type A–4

Tarred Rag Felt, Steep Roofing Pitch, and Slag, for Use Over Homogeneous Roofs Cast in Place

1942

(a) This type of roofing shall be limited to use on poured concrete or poured gypsum decks having a slope more than 2 inches per foot, and not exceeding 6 inches per foot. The concrete or gypsum shall permit of nailing, or treated wood nailing strips shall be provided. Where treated nailing strips are provided, they shall be placed parallel with the incline of the roof and be spaced not more than 3 feet apart.

(b) This type of roofing shall be composed of 5 layers of not less than 14-pound tarred rag felt and a minimum of 175 pounds of steep roofing pitch and 250 pounds of roofing slag per 100 square feet.

(c) Lay 5 plies of 14-pound tarred rag felt over the entire surface, at right angles to the incline of the roof, lapping each sheet 26 inches over the preceding sheet for 32-inch wide felt, or 30 inches for 36-inch wide felt, with end laps of not less than 4 inches. Each sheet shall be nailed with 1-inch barbed roofing nails, through flat tin or zinc discs, 8 inches from the upper edge of the sheets, and with nails not more than 1 foot apart. Where nailing strips are used, the felt shall be nailed with 2-inch nails through flat tin or zinc discs at each nailing strip, with the nails spaced 6 inches and 8 inches, respectively, from the upper edge of each sheet.

(d) Mop back on each sheet, the full distance of the lap, with steep roofing pitch. The felt shall follow and shall be firmly embedded in the hot mopping as applied. Care should be taken that the pitch moppings are even with the lower edge of each overlying sheet, and that the finished felt surface is clean and free from pitch drippings.

(e) Flashings shall be installed at the intersections of the roof with vertical surfaces, and the plans will show whether sheet metal or felt flashings are to be used.

Where metal flashings are called for, they shall be furnished and installed in accordance with Paragraph 1104, Section XI, Sheet Metal Work, and, in addition, the felt and pitch reinforcement shall be installed as follows:

After all plies of roofing have been laid, and before application of the slag, the contractor shall set in separately at the angle of the roof deck and vertical surfaces, 3 plies of 14-pound tarred felt cemented together with steep roofing pitch. These plies shall extend out on the roof at least 4 inches and up the vertical surfaces 6 inches. The last ply shall be coated with steep roofing pitch, and then the metal base and counter flashing installed as specified in Section XI. The flange of the base flashing on the roof shall be coated with hot steep roofing pitch, into which shall be bedded a 4-inch strip of felt centered over the nailing course. This strip shall be coated with hot steep roofing pitch, into which shall be bedded a second strip of felt 6 inches wide and completely covering the first.

Where felt flashings are called for, they shall consist of 3 layers of 14-pound asphalt felt and a cap flashing of mineral-surfaced roll roofing, conforming to current ASTM Specifications D 249. The felt strips shall be cemented to the roof and the vertical surfaces, and to each other, with an approved plastic roofing cement, reinforced with mineral fibre.

The first strip of felt shall extend 6 inches up the vertical surface and 4 inches out on the roof; the second 8 inches up the wall and 5 inches out on the roof; and the third 10 inches up the wall and 6 inches out on the roof. Felt strips shall not exceed 10 feet in length and shall be lapped at least 1 inch at all joints; all joints shall be broken. The cap flashing of mineral-surface roofing shall extend at least 4 inches in masonry walls and down to the roof deck, and shall be cemented to the base flashing with plastic roofing cement.

(g) Using a mop, a uniform coating of steep roofing pitch shall be spread over the entire surface of the roof, using not less than 50 nor more than 60 pounds of pitch per 100 square feet. Into this, while hot, embed 250 pounds of roofing slag per 100 square feet. In cold weather, the slag shall be heated before being applied.

Report on Assignment 2

Preparation of Specifications for Railway Buildings

F. R. Judd (chairman, subcommittee), C. E. Booth, H. M. Church, Hugo Filippi, A. C. Irwin, L. P. Kimball, H. C. Lorenz, L. W. Smith, A. B. Stone.

The committee presents herewith as information, specifications covering welded structural steel and iron for use in buildings with intent to subsequently recommend their adoption for publication in the Manual, and will appreciate criticism and comment thereon.

XII

1203. WELDED STRUCTURAL STEEL AND IRON

A. General

1. Scope

(a) Under this heading shall be included the furnishing, fabrication, erection, inspection, and in some instances the design of all structural steel and iron as shown on drawings, specified or implied as being necessary. All welding shall be by the electric shielded arc method except as hereinafter provided.

(b) Contracts which terminate with fabrication and delivery shall include the preparation of field electrode filler material lists. The contract shall also include the furnishing of this material which may be required for erection. The amount of this material shall be, at least, 15 percent in excess of the estimated actual requirement. Such contract shall not include the furnishing of any devices to hold the component parts together previous to welding, guys, or other temporary parts or devices.

(c) If any riveting or bolting is to be done in connection with this contract, it shall be performed in accordance with Specification 1201, Structural Steel and Iron.

(d) Oxy-acetylene or gas welding may be used only upon written consent of the Engineer.

2. Plans

(a) See Section XII–1201, Structural Steel and Iron, Article 2(a)—AREA Specifications for Buildings for Railway Purposes.

(b) See Section XII–1201, Structural Steel and Iron, Article 2(b).

(c) See Section XII–1201, Structural Steel and Iron, Article 2(c).

B. Material

3. Material

(a) See Section XII–1201, Structural Steel and Iron, Article 3(a).

(b) Filler material shall conform to the American Welding Society's current specifications for iron and steel arc welding electrodes.

(c) See Section XII–1201, Structural Steel and Iron, Article 3(c).

(d) See Section XII–1201, Structural Steel and Iron, Article 3(d).

(e) See Section XII–1201, Structural Steel and Iron, Article 3(e).

(f) See Section XII–1201, Structural Steel and Iron, Article 3(f).

(g) See Section XII–1201, Structural Steel and Iron, Article 3(g).

(h) The surfaces to be joined by welding shall be clean and free from corrosion, oil, water or other foreign matter.

C. Loads and Forces

4. Loads and Forces

(a) See Section XII–1201, Structural Steel and Iron, Article 4(a).
(b) See Section XII–1201, Structural Steel and Iron, Article 4(b).
(c) See Section XII–1201, Structural Steel and Iron, Article 4(c).
(d) See Section XII–1201, Structural Steel and Iron, Article 4(d).
(e) See Section XII–1201, Structural Steel and Iron, Article 4(e).
(f) See Section XII–1201, Structural Steel and Iron, Article 4(f).
(g) See Section XII–1201, Structural Steel and Iron, Article 4(g).

5. Reversal of Stresses

See Section XII–1201, Structural Steel and Iron, Article 5.

6. Combined Stresses

(a) See Section XII–1201, Structural Steel and Iron, Article 6(a).
(b) See Section XII–1201, Structural Steel and Iron, Article 6(c).

7. Members Carrying Wind Only

See Section XII–1201, Structural Steel and Iron, Article 7.

8. Composite Beams

(a) See Section XII–1201, Structural Steel and Iron, Article 8(a).
(b) See Section XII–1201, Structural Steel and Iron, Article 8(b).
(c) See Section XII–1201, Structural Steel and Iron, Article 8(c).
(d) See Section XII–1201, Structural Steel and Iron, Article 8(d).
(e) See Section XII–1201, Structural Steel and Iron, Article 8(e).

9. Effective Span Length

(a) See Section XII–1201, Structural Steel and Iron, Article 9(a).
(b) See Section XII–1201, Structural Steel and Iron, Article 9(b).

10. Members Carrying Railway Tracks

See Section XII–1201, Structural Steel and Iron, Article 10.

11. Members Carrying Driveways

See Section XII–1201, Structural Steel and Iron, Article 11.

D. Unit Stresses

12. Allowable Unit Stresses

All parts of the structure shall be so proportioned that the unit stresses in pounds per square inch shall not exceed the following values:

(a) Structural Steel.

Tension.	*Pounds per Square Inch*
Structural steel, net section	20,000
Shielded arc, V or butt welds	16,250
Shielded arc, fillet welds	13,600
Hangers, rods and bolts, not upset for thread, net section	15,000
Hangers, rods and bolts, upset for thread, net section	20,000

Compression.

Columns, gross section.

For axially loaded columns with values of $\frac{l}{r}$ not greater than 120 ..... $17{,}000 - 0.485\frac{l^2}{r^2}$

For axially loaded columns with values of $\frac{l}{r}$ greater than 120 ..... $\dfrac{18{,}000}{1 + \dfrac{l^2}{18{,}000r^2}}$

in which l is the unbraced length of the column and r is the corresponding radius of gyration of the section, both in inches. (For working stresses, see Appendix "C").

Plate girder stiffeners, gross section	20,000
Webs of rolled sections at toe of fillet (Crippling, See Article 21 (j)	24,000
Shielded arc, V and butt welds	18,750
Shielded arc, fillet welds	13,600

Bending.

Tension on extreme fibers of rolled sections, plate girders and built-up members (See Article 22 (a)) 20,000

Compression on extreme fibers of rolled sections, plate girders and built-up members, for values of $\frac{l}{b}$ no greater than 40 $\dfrac{22{,}500}{1 + \dfrac{l^2}{1{,}800b^2}}$

with a maximum 20,000

in which l is the laterally unsupported length of the member and b is the width of the compression flange, both in inches.

Stress on extreme fibers of pins 30,000

Shearing.

Shielded arc, V or butt welds	14,300
Shielded arc, fillet welds	13,600
Pins in reamed or drilled holes	15,000
Webs of beams and plate girders, gross section	15,000

Bearing.	*Double Shear*	*Single Shear*
Turned bolts in reamed or drilled holes	40,000	32,000
Unfinished bolts	25,000	20,000
Turned pins in reamed or drilled holes	32,000	
(Bolts may be used only at the discretion of the Engineer).		

Contact Area.

Milled stiffeners and other milled surfaces	30,000
Fitted stiffeners	27,000

Expansion rollers and rockers (pounds per linear inch) .... 600 d
in which d is the diameter of roller or rocker in inches.

(b) Cast Steel.

See Section XII–1201, Structural Steel & Iron, Article 12(b).

(c) Cast Iron.

See Section XII–1201, Structural Steel & Iron, Article 12(c).

(d) Masonry (Bearing).

See Section XII–1201, Structural Steel & Iron, Article 12(d).

E. Design

13. Strength of Welds

In calculating the strength of welds, the unit stresses employed shall be the same as those given in Section 4, Unit Stresses.

The area of V and butt welds shall be determined my multiplying the thickness of the weld by its length. The thickness of the weld shall in no case exceed the depth of the V.

The area of fillet welds shall be determined by multiplying the thickness of the throat of the fillet by its length.

14. Slenderness Ratios

The ratio of unbraced length to least radius of gyration shall not exceed:

For main compression members	120
For bracing and other secondary members in compression	200
For cast iron columns	100
For welded tension members	300

15. Depth Ratios

See Section XII–1201, Structural Steel and Iron, Article 14.

16. Unsupported Compression Flanges

See Section XII–1201, Structural Steel and Iron, Article 15.

17. Minimum Thickness of Material

(a) See Section XII–1201, Structural Steel and Iron, Article 16(a).

(b) Gusset plates (if necessary) for trusses with end reactions greater than 35,000 pounds shall be not less than ⅜ inch thick.

Webs of girders shall be not less than $\frac{5}{16}$ inch thick.

Sole plates or bed plates shall be not less than ½ inch thick.

Anchor bolts preferably shall be not less than 1 inch in diameter.

(c) See Section XII–1201, Structural Steel and Iron, Article 16(c).

(d) In compression members consisting of segments connected by cover plates or lacing, or segments connected by webs, the thickness of the webs of the segments shall be not less than $\frac{1}{32}$ of the unsupported distance between the nearest weld lines, or the roots of the flanges in case of rolled sections. The thickness of the cover plates or webs connecting the segments shall be not less than 1/40 of the unsupported distance between the nearest lines of their connecting welds, or the roots of their flanges in case of rolled sections.

(e) See Section XII–1201, Structural Steel and Iron, Article 16(e).

18. Gross and Net Sections

(a) The gross section of a member at any point shall be determined by summing the products of the thickness and the gross width of each element as measured normal to the axis of the member. The net section shall be determined by substituting for the gross width, the net width computed in accordance with paragraphs (c) to (e) of Article 18.

(b) See Section XII–1201, Structural Steel & Iron, Article 17(b).

(c) Sections shall be made symmetrical wherever practicable. The effective area of single angles in tension shall be assumed as the area of the connected leg plus 50 percent of the area of the unconnected leg. Single angles connected by lug angles shall be considered as connected by one leg.

(d) For angles, the gross width shall be the sum of the widths of the legs less the thickness.

(e) For splice members, the thickness considered shall be only that part of the thickness of the member which has been developed by welding beyond the section considered.

(f) See Section XII–1201, Structural Steel & Iron, Article 17(h).

(g) In all pin-connected members, the net width across the pin hole, transverse to the axis of the member, shall preferably not exceed 8 times the thickness of the member at the pin.

19. Expansion

(a) See Section XII–1201, Structural Steel & Iron, Article 18(a).

(b) See Section XII–1201, Structural Steel & Iron, Article 18(b).

20. Connections

(a) Connections carrying calculated stresses, except for lacing, sag bars, and girts, shall have not less than 2 welds.

(b) See Section XII–1201, Structural Steel & Iron, Article 19(b).

(c) The welds at the ends of any member transmitting stresses into that member should preferably have their centers of gravity on the gravity axis of the member; otherwise, provision shall be made for the effect of the resulting eccentricity. Pins may be so placed as to counteract the effect of bending due to dead load.

(d) See Section XII–1201, Structural Steel & Iron, Article 19(d).

(e) See Section XII–1201, Structural Steel & Iron, Article 19(e).

(f) Fillers under plate girder stiffeners at end bearings or points of concentrated loads shall be secured by sufficient welds to prevent excessive bending and bearing stresses.

(g) Compression members when faced for bearing shall be spliced sufficiently to hold the connecting members accurately in place. Other welded joints, whether in tension or compression, shall be spliced so as to transfer the stress to which the member is subject.

21. Plate Girders and Rolled Beams

(a) Plate girders, cover-plated beams, and rolled beams shall in general be proportioned by the moment of inertia of the gross section. If such members contain holes, as for bolts, or pins, the full deduction for such holes shall be made. The deductions thus applicable to either flange shall be made also for the opposite flange if the corresponding holes are there present.

(b) See Section XII–1201, Structural Steel & Iron, Article 22(b).

(c) See Section XII–1201, Structural Steel & Iron, Article 22(c).

(d) Unstiffened cover plates shall not extend more than 6 inches nor more than 12 times the thickness of the thinnest plate beyond the weld connecting them to the angles. The total cross sectional area of cover plates shall not exceed 70 percent of the total flange area.

(e) Welds connecting the flanges to the web shall be proportioned to resist the horizontal shear due to bending as well as any loads applied directly to the flange.

(f) Stiffeners shall be placed on the webs of plate girders at the ends and at points of concentrated loads. Such stiffeners shall have a close bearing against the flanges, shall extend as closely as possible to the edge of the flange angles, and shall not be crimped. They shall be connected to the web by enough welds to transmit the stress.

Only that portion of the outstanding legs outside of the fillets of the flange angles shall be considered effective in bearing.

(g) See Section XII–1201, Structural Steel & Iron, Article 22(g).

(h) See Section XII–1201, Structural Steel & Iron, Article 22(h).

(i) See Section XII–1201, Structural Steel & Iron, Article 22(i).

(j) Plate girder stiffeners shall be in pairs, one on each side of the web, and shall be welded to the web with 2 continuous welds.

(k) See Section XII–1201, Structural Steel & Iron, Article 22(k).

(l) See Section XII–1201, Structural Steel & Iron, Article 22(l).

(m) See Section XII–1201, Structural Steel & Iron, Article 22(m).

(n) See Section XII–1201, Structural Steel & Iron, Article 22(n).

22. Separators

See Section XII–1201, Structural Steel & Iron, Article 23.

23. Tie Plates

(a) The open sides of compression members shall be provided with lacing having tie plates at each end, and at intermediate points if the lacing is interrupted. Tie plates shall be as near the ends as practicable. In main members carrying calculated stresses, the end tie plates shall have a length of not less than the distance between the connections to the segments of the member, and intermediate ones of not less than ½ of this distance. The thickness of tie plates shall be not less than 1/50 of this distance.

(b) Tie plates shall be used to secure the parts of tension members composed of shapes. They shall have a length not less than ⅔ of the length specified for tie plates in compression members. The thickness shall be the same as in paragraph (a) above.

24. Lacing

(a) See Section XII–1201, Structural Steel & Iron, Article 25(a).

(b) Lacing bars shall be proportioned to resist a shearing stress normal to the axis of the member equal to 2 percent of the total compressive stress in the member. In determining the section required, the compression formula shall be used, l being taken as the length of the bar between the welds connecting it to the segment for single lacing and 70 percent of that distance for double lacing. The ratio $\frac{l}{r}$ shall not exceed 140 for single lacing nor 200 for double lacing.

(c) The thickness of lacing bars shall be not less than 1/40 for single lacing, and 1/60 for double lacing, of the distance between welds.

(d) The inclination of lacing bars to the axis of the members shall preferably be not less than 45 degrees for double lacing and 60 degrees for single lacing. When the distance between the weld lines in the flanges is more than 15 inches, the lacing shall be double and welded at the intersection if bars are used, or else shall be made of angles.

25. Adjustable Members

See Section XII–1201, Structural Steel & Iron, Article 26.

26. Column Bases

(a) See Section XII–1201, Structural Steel & Iron, Article 27(a).

(b) See Section XII–1201, Structural Steel & Iron, Article 27(b).

(c) See Section XII–1201, Structural Steel & Iron, Article 27(c).

27. Anchor Bolts

See Section XII–1201, Structural Steel & Iron, Article 28.

F. Fabrication

28. Workmanship

(a) See Section XII–1201, Structural Steel & Iron, Article 29(a).

(b) See Section XII–1201, Structural Steel & Iron, Article 29(b).

(c) See Section XII–1201, Structural Steel & Iron, Article 29(c).

(d) All welding shall be done by the electric arc process, except when permission to employ some other process is given in writing by the Engineer.

(e) The edges of plates and sections to be welded shall be adequately closed by service bolting, clamping, jigs or tack welds. Effective means shall be taken to prevent distortion of the parts during welding.

(f) See Section XII–1201, Structural Steel & Iron, Article 29(g).

(g) Compression joints depending upon contact bearing shall have the bearing surfaces truly machined to a common plane after the members are welded. All other joints shall be cut straight.

(h) See Section XII–1201, Structural Steel & Iron, Article 29(k).

(i) See Section XII–1201, Structural Steel & Iron, Article 29(l).

(j) See Section XII–1201, Structural Steel & Iron, Article 29(m).

(k) See Section XII–1201, Structural Steel & Iron, Article 29(n).

(l) See Section XII–1201, Structural Steel & Iron, Article 29(o).

(m) See Section XII–1201, Structural Steel & Iron, Article 29(p).

(n) See Section XII–1201, Structural Steel & Iron, Article 29(q).

29. Shop Welding

(a) The surface of the parts to be welded shall be clean and free from paint, heavy scale or any substance which might deleteriously affect the quality of the weld.

(b) The edges of plates and sections to be welded shall be adequately closed by service bolting, clamping, jigs or tack welds. Effective means shall be taken to prevent distortion of the parts during welding.

(c) Weld shall be made with runs of good, clean metal free from slag inclusions or porosity. The slag shall be removed after making each run and for this purpose, a light hammer may be used.

(d) The utmost care shall be taken to avoid undercutting, but where this occurs unavoidably, the reduction in section at that point shall be made good to the satisfaction of the Engineer by an additional run of weld metal.

(e) Butt welds on plates, or sections of greater thickness than $\frac{3}{16}$ inch and fillet welds of greater leg length than $\frac{5}{16}$ inch shall be built up with several deposits of metal in order to secure the annealing effect of each successive deposit.

Runs or Depositions for Fillet and Butt Welds

Size of Weld Inches	*Butt Weld*	*Fillet Weld*
$\frac{3}{16}$	1	1
$\frac{1}{4}$	2	1
$\frac{5}{16}$	2	1 or 2
$\frac{3}{8}$	2	2 Min.
$\frac{7}{16}$	4	2 Min.
$\frac{1}{2}$	4 Min.	3 Min.
$\frac{5}{8}$	5 Min.	5 Min.
$\frac{3}{4}$	6 Min.	6 Min.
$\frac{7}{8}$	8 Min.	7 Min.
1	12 Min.	11 Min.

The stipulations of this table do not apply to welds made in a vertical or overhead position.

(f) The contour of the weld shall have a smooth finish and shall indicate good fusion with the parent metal. Welds showing lack of fusion, poor penetration, and porosity, or welds in which the weld metal tends to fold over on the parent metal without proper penetration, shall be cut out and rewelded.

(g) Edges and ends to be welded shall be cut to shape, and beams or other sections shall be cut to length by machining or planing, unless otherwise approved by the Engineer. If flame cutting is permitted, the surfaces shall be chipped or ground free from scale before welding.

(h) Only experienced welders in this type of work shall be used on the work.

30. Camber

See Section XII–1201, Structural Steel & Iron, Article 30.

31. Shop Painting

(a) See Section XII–1201, Structural Steel & Iron, Article 31(a).
(b) See Section XII–1201, Structural Steel & Iron, Article 31(b).
(c) See Section XII–1201, Structural Steel & Iron, Article 31(c).
(d) See Section XII–1201, Structural Steel & Iron, Article 31(d).
(e) See Section XII–1201, Structural Steel & Iron, Article 31(e).

G. Inspection

32. Inspection

(a) See Section XII–1201, Structural Steel & Iron, Article 32(a).
(b) See Section XII–1201, Structural Steel & Iron, Article 32(b).
(c) See Section XII–1201, Structural Steel & Iron, Article 32(c).

H. Weighing and Shipping

33. Weight Paid for

See Section XII–1201, Structural Steel & Iron, Article 33.

34. Variation in Weights

(a) See Section XII–1201, Structural Steel & Iron, Article 34(a).
(b) See Section XII–1201, Structural Steel & Iron, Article 34(b).

35. Computed Weight

(a) See Section XII–1201, Structural Steel & Iron, Article 35(a).
(b) See Section XII–1201, Structural Steel & Iron, Article 35(b).
(c) See Section XII–1201, Structural Steel & Iron, Article 35(c).
(d) See Section XII–1201, Structural Steel & Iron, Article 35(d).
(e) The weight of filler metal in welds shall be included in the computed weight.
(f) See Section XII–1201, Structural Steel & Iron, Article 35(f).

36. Weights of Members

See Section XII–1201, Structural Steel & Iron, Article 36.

37. Gross Weight Payment

See Section XII–1201, Structural Steel & Iron, Article 37.

38. Marking and Shipping

(a) Members weighing more than 5 tons shall have the weight marked thereon. Filler weld metal, pins and other small parts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each package, box or crate.

(b) See Section XII–1201, Structural Steel & Iron, Article 38(b).

I. Erection

39. General

(a) See Section XII–1201, Structural Steel & Iron, Article 39.

(b) All welding in the field shall be done in accordance with the preceding specifications, Section 29, Shop Welding.

40. Drawings

Where the fabricated material is furnished by others, the Company will furnish complete detail drawings for the work, including shop details, erection diagrams, match marking diagrams, bill of filler metal, and a copy of shipping statements.

41. Delivery of Material

See Section XII–1201, Structural Steel & Iron, Article 41.

42. Handling and Storage of Materials

See Section XII–1201, Structural Steel & Iron, Article 42.

43. Masonry

See Section XII–1201, Structural Steel & Iron, Article 43.

44. Bearings and Anchorage

(a) See Section XII–1201, Structural Steel & Iron, Article 44(a).

(b) See Section XII–1201, Structural Steel & Iron, Article 44(b).

45. Methods and Equipment

See Section XII–1201, Structural Steel & Iron, Article 45.

46. Workmanship

(a) See Section XII–1201, Structural Steel & Iron, Article 46(a).

(b) See Section XII–1201, Structural Steel & Iron, Article 46(b).

(c) See Section XII–1201, Structural Steel & Iron, Article 46(c).

(d) No welding shall be done until the structure or its component parts have been properly aligned.

(e) All welds, also all serious abrasions to the shop coat, shall be spot painted with the material used for the shop coat, or an equivalent, and all mud and other firmly attached and objectionable foreign materials shall be removed before general field painting. Unless otherwise specified, general field painting is not included under this heading.

47. Misfits

See Section XII–1201, Structural Steel & Iron, Article 47.

48. Superintendence and Workmen

See Section XII–1201, Structural Steel & Iron, Article 48.

49. Interference with Traffic

See Section XII–1201, Structural Steel & Iron, Article 49.

50. General Conditions

(a) See Section XII–1201, Structural Steel & Iron, Article 50(a).
(b) See Section XII–1201, Structural Steel & Iron, Article 50(b).

Appendix A

See Section XII–1201, Structural Steel & Iron, Appendix A.

Appendix B

See Section XII–1201, Structural Steel & Iron, Appendix B.

Report on Assignment 3

Railroad Warehouse Requirements for Handling Quick Frozen Products

E. Christiansen (chairman, subcommittee), W. T. Dorrance, E. G. Hewson, N. D. Howard, E. K. Mentzer, C. P. Schantz, E. W. Scripture, Jr., L. W. Smith, A. L. Sparks, O. G. Wilbur.

The committee submits its completed report on this assignment as information.

Definition

Quick frozen products are those food products, vegetables, fruit, fish, poultry, and meat which are frozen at low temperatures and at such a rate that the ice crystals formed are small, close-grained and not of sufficient size to penetrate the cell walls. Freezing temperatures vary widely, depending on the nature of the product over a range of 0 deg. F. to –90 deg. F. The methods of freezing are also quite diverse including direct contact with cooled metal plates, immersion in a liquid, and freezing in a stream of gas. Freezing is carried out either before or after packing. The purpose of quick freezing is the preservation of selected foods with minimum change in flavor, appearance and food value.

The necessity for the quick freezing of fruit, vegetables, and meat is dependent upon immediate freezing of the product as it comes from the tree, plant, or killing rooms. There can be no justification for shipping fruits and vegetables to be quick frozen from one territory to another before freezing since the resultant product would be inferior if this interim between picking and freezing were introduced.

A product which has been partially defrosted should never be replaced in storage in the ordinary manner of stacking in a closed stack. Such products should be placed in open stacks, provided with ample air circulation so as to reduce the temperature of the product as rapidly as possible. Warehouses should be designed to provide this facility.

Development and Growth

The quick freezing industry had its inception in 1924 but has developed rapidly since 1932. In 1932 fish and meat products were readily quick frozen in relatively large quantities while quick frozen vegetables and fruits were first being introduced. In that year one company distributed 10 million pounds of quick frozen products and six years later, in 1938, the total distribution was in excess of 250 million pounds.

Although there has been a continuous depression since, activities in the production of quick frozen products have reached substantial proportions, the demand for these commodities has brought about a sustained and continued development in freezing plants, transportation facilities and storage plants. During one recent 12-month period, 12 new freezing plants were constructed and major additions made to 15 of the plants previously in operation.

Location of Warehouses

Warehouses for handling quick frozen products should be served by house tracks so located that when cars are set and opened for unloading, there will be no need for moving or disturbing the car until unloading is completed. The cars should be protected by proper derails or other safety measures. Speed is essential in loading and unloading, which is generally done with hand trucks.

One cold storage operator interviewed, who owns and operates a large cold storage house which is equipped with a conveyor system for loading and unloading cars, has discontinued its use as he has no difficulty in unloading a car in about 30 min. by hand and since, in loading a car, considerable time is required to properly arrange and stack the load, the conveyor proved to be of no advantage. The warming of a car while unloading is not of great importance as the load is quickly transferred to a cold room. but it is of great importance when loading.

There should be some form of adjustable, telescoped, insulated vestibule connection between the building and the car, sufficiently large to allow for the operation of the doors on both car and building. It should be so arranged and be sufficiently tight to allow for a free circulation of low temperature air from the building out into the car. It should also be so arranged that it can be connected to and disconnected from car quickly and pushed back to provide permissible clearance. With such arrangement the car can be cooled by the house refrigerating machinery to the required temperature before it is loaded and maintained at the same temperature during loading until it is sealed for shipment.

Design of Warehouses

The same type of construction specified for general cold storage plants may also be used for quick frozen products provided the insulation is increased in thickness to insure constant temperatures of –5 deg. F. to –10 deg. F. for storage and around –30 deg. F. for freezing rooms.

The arrangement, number and sizes of rooms will, of course, depend upon the volume of business but where volume justifies, there should be a receiving room, two or more storage rooms, a freezing room and a work room. Where large quantities are stored, rooms 50 ft. by 100 ft. seem convenient for bulk storage and may be larger if desired. It is suggested that smaller rooms, about 25 ft. by 50 ft., should also be provided for the quick moving stock, which can be moved in from the large bulk stock rooms, thereby relieving the necessity for too frequently opening the larger rooms. The large and small storage rooms should connect with each other and where possible both rooms should connect with the receiving room or corridor and the latter should have vestibules at outside doors.

A small room for freezing and for machinery should be provided, located, preferably, near the car loading door and near the bulk storage room. A small work room should be provided in which to assemble and wrap goods for local delivery. There should also be provision for office and toilets and, where required, a cold storage locker room for renting to individual customers. Lockers of various types are used, including

built-in lockers, made of wood or steel framing, enclosed with wire mesh; also factory built enameled sheet steel cabinets. The built-in wire mesh type seems to be more popular with cold storage operators as the cold air circulates about it more freely. The lockers are generally of about 12 cu. ft. capacity and are about 3 ft. deep from front to back. A ceiling height of 10 ft. is recommended.

All storage and locker rooms and all corridors should have floors, walls and ceilings insulated to insure a constant temperature of –10 deg. F. Freezer rooms should be insulated for a temperature of –30 deg. F.

Doors to all insulated rooms should be of standard refrigerator door construction insulated for the above temperatures and should be of ample width to avoid interference from any overhang on the sides of the truck that may be encountered, due to the manner of loading and handling the truck and commodity.

Transportation

It seems that there are many problems yet to be solved before quick frozen products may be satisfactorily handled from farmer to consumer through a line of independent harvesters, packers, freezers, shippers, brokers, distributors and retailers because a misstep in the handling by any one of the chain may seriously affect the quality of the product and result in loss and damage. When quick frozen food is taken from the freezer rooms at sub-zero temperatures, shipped a long distance, transferred from cars to distributor's warehouse with temperatures of 0 deg. F. to –5 deg. F. and from warehouse by automobile truck to the retailer's store, there is divided responsibility which can easily result in considerable argument in the adjustment of claims. There should be some assurance that sealed packages received by the railroad from the shipper contain products which unquestionably measure up to requirements.

The cellular structure of fruits and vegetables is preserved in its natural state by the quick freezing process but when once subjected to a warmer temperature and then to a colder one, it is started on a breaking down process; however, food thus damaged may not be a total loss as it may or may not be sold at reduced prices.

From the time of the introduction of mass shipments of perishable fresh edibles, refrigeration and transportation have been necessarily interdependent. Not only were the early owners of transportation systems deeply interested in the refrigerated shipment of perishables, but they found it necessary to establish storage houses at transfer and consumer centers to provide refrigerated distribution of the perishables delivered. Rail transportation designed on any artery system made necessary an equally extensive refrigerated warehouse storage.

By far the greater amount of rail refrigeration for quick frozen products has been made with salt ice. In general a bunker mixture of 70 percent ice and 30 percent salt is used in what is termed super-insulated refrigerated cars.

Portable frozen food refrigerated containers of various sizes from small packages to box size have been developed for the successful transportation of quick frozen foods over short routes. Usually the small packages are refrigerated with dry ice. Some of them have developed to a point where one insulated box will develop two storage compartments of varying temperature control. Due to the great size of earlier containers, it was found advisable to develop smaller units that would be handled by one or two men and would not be too high to pass through the door of a baggage car.

In December 1938, the Railway Express Company announced that it would inaugurate refrigerator container service using the Church CO_2 container for less carload shipments. For this class of shipments, methods of handling seem to be definitely in the development stage.

There appear to be two essential requirements for the protection of quick frozen products during transportation and distribution. These are

1. The products must be maintained at a low temperature of about 0 deg. F.
2. Temperature fluctuations must be avoided so that the permissible temperature range for storage shall be maintained between 0 deg. F. to –5 deg. F.

In order to satisfy these requirements, certain precautions in addition to that of maintaining the storage space within this temperature range must be taken.

The ability of refrigerator cars to carry quick frozen commodities at low temperatures is materially assisted by placing quick frozen products in a car already at zero or lower. Because of this it is necessary that means be provided to cool the car before loading and to maintain the car, the storage space and the products at as nearly as possible the same temperature during loading. To accomplish this the distance between storage and car should be reduced to a minimum and the space protected by an insulated enclosed runway. The same considerations apply to loading from storage into trucks for retail distribution.

It is important in storing quick frozen products that storing against the walls of adjoining rooms or against outside walls shall be prevented to avoid fluctuations in temperature due to possible differences between the storage space and adjoining spaces. It is also essential that floor racks be provided for the same reason.

Excessive air circulation among stacks should be avoided as it will cause excessive evaporation of moisture from the products. Unit coolers are sometimes the source of great loss of moisture during storage.

Conclusion

No special provision in terminal or local freight warehouses is recommended for handling quick frozen products. In the larger cities cars are generally unloaded into large cold storage plants where the bulk storage is held until it is delivered by automobile trucks to the local distributor's small warehouses.

The trade in the smaller cities is supplied by l.c.l. shipments from the cold storage plants in the larger cities and the products are hauled by trucks to small local cold storage plants or direct to the retailer.

Retailers selling products of the larger advertised brands of quick frozen foods are provided with refrigerator cases made for that purpose which are capable of holding the food within the required temperature range for several weeks.

Report of Committee 14—Yards and Terminals

C. H. Mottier, *Chairman,*
J. R. W. Ambrose
C. E. Armstrong
J. E. Armstrong
C. J. Astrue
H. Austill
Hadley Baldwin
H. G. Basquin
A. L. Becker
V. J. Bedell
W. O. Boessneck
N. C. L. Brown
H. F. Burch
H. H. Clark
W. F. Cummings
H. G. Dalton
F. T. Darrow
M. H. Dick
R. B. Elsworth
W. H. Giles
E. D. Gordon
R. J. Hammond
G. F. Hand
M. J. J. Harrison
H. H. Harsh
E. M. Hastings
H. O. Hem
W. H. Hobbs
J. M. Hood
E. T. Johnston
J. S. Knight
E. K. Lawrence
H. C. Lorenz
L. L. Lyford
W. J. Hedley, *Vice-Chairman*
C. A. Mitchell
H. C. Propst
C. L. Richard
H. L. Ripley
H. M. Roeser
W. B. Rudd
W. C. Sadler
C. U. Smith
J. W. Smith
D. J. Strauch
J. N. Todd
E. E. R. Tratman
E. P. Vroome
V. R. Walling
R. W. Willis
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   No report. However, certain revisions of and additions to the Manual are recommended in connection with report on Subject 2 ..... page 142

2. Terminal facilities required for servicing electrical and air conditioning equipment in passenger cars, collaborating with Committee 1—Power Supply, Electrical Section, Engineering Division, AAR.

   Final report, submitted as information—except revision of Manual material, which is submitted for adoption ..... page 142

3. Scales used in railway service.

   Brief progress statement, presented as information ..... page 143

4. Classification yards, collaborating with Committee 16—Economics of Railway Location and Operation.

   Progress report, submitted as information ..... page 143

5. Produce terminals.

   No report.

6. Effect of lengthening of locomotive runs on location and arrangement of locomotive servicing facilities.

   No report.

7. Modernization of passenger terminals.

   Progress report, submitted as information ..... page 149

8. Bibliography on subjects pertaining to yards and terminals appearing in current periodicals.

Progress report, submitted as information ..... page 158

THE COMMITTEE ON YARDS AND TERMINALS,
C. H. MOTTIER, *Chairman.*

Report on Assignment 2

Terminal Facilities Required for Servicing Electrical and Air Conditioning Equipment in Passenger Cars

Collaborating with Committee 1—Power Supply, Electrical Section, Engineering Division, AAR

W. J. Hedley (chairman, subcommittee), J. R. W. Ambrose, C. J. Astrue, A. L. Becker, H. G. Dalton, W. H. Giles, W. H. Hobbs, J. S. Knight, H. C. Lorenz, C. A. Mitchell, C. H. Mottier, C. U. Smith, V. R. Walling.

Report on this assignment was made in full last year, except that definite recommendations for the location and spacing of electrical outlets were withheld pending the completion of your committee's investigation. A thorough canvass has been made by questionnaire submitted jointly by this committee and Committee 1—Power Supply, Electrical Section, through the secretary's office. Replies were received from 51 lines and terminal companies.

Summary of the replies indicates that the constant potential, or modified constant potential method of battery charging is favored over the constant current method, and that the use of portable motor generator sets (buggies) operating from 220-volt a.c. is rather generally favored for battery charging at small terminals and for special requirements at other locations.

Your committee recommends the following changes and additions for publication in the Manual:

Passenger Terminals

Page 14–17, add new section as follows:

2420. Electrical Service Outlets at Station Tracks

Electrical service outlets at station tracks should preferably be located between adjacent tracks, except in stations having separate trucking platforms. Direct current battery charging outlets, when serving two tracks, should have two receptacles and should be located at intervals of two average car lengths along those tracks used regularly for holding passenger cars for extended periods. Air conditioning outlets for 220-volt alternating current, when serving two tracks, should have two receptacles, and should be located at intervals of one average car length along those tracks used regularly for holding either direct-mechanical or electro-mechanical air conditioned passenger cars.

25. Coach Yards

252. Layouts and Details

Delete paragraph 252 (t), page 14–18, reading as follows:

(t) *Electrical supply connections should be spaced the same as water hydrants, but a minimal distance apart equivalent to twice the average length of cars.*

Insert in its place the following paragraph:

(t) Electrical service outlets in coach yards having alternately wide and narrow track centers, should preferably be located in the center of the narrow service platform. In coach yards having uniform track centers, outlets should preferably be located at the edge of the platform, each outlet serving only one track. Direct current battery charging outlets when serving two tracks, should have two receptacles and should be located at intervals of one average car length. When serving only one track, outlets may be located either at intervals of one average car length, with one receptacle, or at intervals of two average car lengths, with two receptacles. Air conditioning outlets for 220-volt alternating current, when serving two tracks, should have two receptacles and should be located at intervals of either one or two average car lengths, preferably one, along those tracks used for servicing either direct-mechanical or electro-mechanical air conditioned passenger cars. When serving only one track, these outlets may be located at intervals of either one average car length, with one receptacle at each location, or two average car lengths, with two receptacles.

Report on Assignment 3

Scales Used in Railway Service

M. J. J. Harrison (chairman, subcommittee), J. E. Armstrong, Hadley Baldwin, H. G. Basquin, E. D. Gordon, E. M. Hastings, H. O. Hem, E. K. Lawrence, C. H. Mottier, H. C. Propst, C. L. Richard, H. M. Roeser, D. J. Strauch, J. N. Todd, E. P. Vroome.

Last year your committee presented as information, tentative draft of specifications for the manufacture and installation of hand-operated grain-hopper scales (Proceedings for 1941, Volume 42, pp. 114–128, inclusive), and requested comments and criticisms thereon.

Your committee has been active during the year in collaboration with other parties at interest, and has given further study to the ultimate form of the specifications which may be acceptable to all interested parties. It is hoped that a final draft of these specifications may be submitted for approval next year.

Report on Assignment 4

Classification Yards, Collaborating with Committee 16—Economics of Railway Location and Operation

G. F. Hand (chairman, subcommittee), C. E. Armstrong, J. E. Armstrong, C. J. Astrue, Hadley Baldwin, W. O. Boessneck, N. C. L. Brown, H. F. Burch, H. H. Clarke, W. F. Cummings, R. B. Elsworth, W. H. Giles, R. J. Hammond, M. J. J. Harrison, H. H. Harsh, E. M. Hastings, W. H. Hobbs, E. T. Johnston, E. K. Lawrence, L. L. Lyford, C. A. Mitchell, C. H. Mottier, W. B. Rudd, W. C. Sadler, C. U. Smith, J. W. Smith, J. N. Todd, V. R. Walling, R. W. Willis.

This year your committee has selected under its general assignment the subject of Communication at Hump Classification Yards, and submits this report as information on the different methods of communication now in use and their application in connection with different operations in the classification yard from the time trains enter the receiving yard until the departure of trains from the leaving end of the yard.

Communication facilities are important in the economic and efficient handling of traffic in yards and terminals. Many different methods have been devised and used to advantage. Some of these methods are described herein and their advantages are indicated for the various needs for communication in yard operation.

Description of Methods

1. Hand Signals

The first and probably the most used method of communication is the hand signal.

2. Horns or Whistles

Horns or whistles located at strategic points in the yard are controlled from a remote point, and codes are used to indicate specific movements.

3. Telephones

Telephone communication is used extensively, and horns and whistles are frequently used for calling various persons to a telephone.

4. Loud Speaker Systems

Loud speakers are located at various points in the yard, or in towers in retarder yards, and communications are transmitted by voice from a central point. In the case of retarder yards, two-way communication is provided, but when the loud speaker is placed out in the yard it is the usual practice to call the desired person by loud speaker to a telephone for two-way communication.

5. Teletype System

Electrically operated receiving typewriters are located at points where it is desirable to transmit written messages. The master or sending typewriter is located at a central point and connected electrically to the receiving typewriters. The messages typed on the master machine are recorded simultaneously on one or more receiving typewriters.

6. Pneumatic Tubes

To transmit way bills or other written material, a continuous tube is constructed from one location to another and cartridges in which the written material may be deposited are placed in the tubes and driven by compressed air to the location desired.

7. Conveyor Belts

Conveyor belts are sometimes used for transmitting way bills and other written material for short distances, such as between the yard office and the scale house.

8. Wayside Signals

Wayside signals similar to those used for the operation of trains on the main line are employed in yards, principally for the movement of cars toward the hump and for controlling the movement of trimmer engines on humps. The hump signal is located at the hump and its indications frequently are repeated by other signals located in the receiving yard. Aspects are displayed to indicate whether cars are to be humped at fast, medium or slow speeds and whether they are to be stopped or backed up.

The trimmer signal generally is located at the hump and is used to govern movements through the switching area.

9. Cab Signals

Cab signals are used principally to indicate the movement of cars toward the hump. A cab signal consists of a miniature light signal located in the locomotive cab and is controlled by the operation of a controller or switch located usually at the hump. A coded current is passed through a wire attached to the track and this current influences the receiving equipment on the locomotive so that its code can be deciphered and made to operate a relay which, in turn, lights one of the lamps in the signal. The cab signal is generally used to repeat the aspects displayed by the hump signal.

10. Locomotive Communication Systems

Locomotive communication systems may be divided into two classes; one-way or two-way communication, as follows:

(a) One-way communication or the transmission of voice communication from a central station to a locomotive operating in the yard area is accomplished by means of radiating voice-modulated electric energy from an antenna located at the central station or from the rails of the track and a wire located either on a pole line or buried in the ground along the right-of-way. This energy is received with suitable equipment on the locomotive and converted to reproduce the speech through a loud speaker in the locomotive cab for communication to the engineman, or the speaker may be on the front or rear of the locomotive for communication to the conductor, who usually is on the footboard or working on the ground.

(b) Two-way communication or the transmission of voice communication either from a central station to locomotives or from a locomotive to the central station or to other locomotives is accomplished by the same means employed for one-way communication, but is supplemented by sending equipment on the locomotive, whereby voice-modulated electric energy is radiated to be received in the central station or other locomotives. Microphones are located in the locomotive cab for the use of the engineman.

Locomotive communication systems should be equipped with a check signal, audible or visible, or both, which guarantees to the engineman that the central station equipment (as well as the locomotive equipment itself) is functioning.

Application of Methods of Communication

The methods of communication described above are applied in actual practice as indicated below in relation to the various phases of yard operation.

Reception of Trains in Receiving Yard

Information as to the expected time of arrival for each train is usually given to the yard forces by telephone, so that a track in the receiving yard can be selected and the route lined up for moving the train into the yard without stopping. This requires the services of a switchtender or remote-controlled power switches at the entrance end of the receiving yard.

In many yards the traffic is not sufficient to justify the expense of such facilities and the crew of the inbound train lines up its own route. In such cases information must be given to the crew of the inbound train as to the track to be used and occasionally when to use it. Field telephones are sometimes located at the entrance to the receiving yard and instructions are thus given to crews of inbound trains to phone the yardmaster for instructions.

The most inexpensive method is for the hump crew to line the route for the next inbound train after they move in behind the train to be moved to the hump, and for the crew of each inbound train to line the route for the train which might follow it into the yard.

A signal displaying numbers to indicate to the inbound crew the receiving yard track to be used may be located at the entrance to the receiving yard. In such case the crew lines its own route.

Information pertaining to the track on which an arriving train is to be received, and occasionally the number of cars which that track will hold, is sometimes given to the train crew by placing a placard or large number or series of numbers in the window of an interlocking tower located near the entrance end of the receiving yard. By the use of this information, time is saved in receiving trains.

Movement of Road Engine From Receiving Yard to Roundhouse

The road engine after being cut off from its train should be moved to the roundhouse as quickly as possible. Hand signals may be used for bringing the engine out of the receiving yard. However, it is necessary to coordinate this movement with other operations at the hump, and unless communications are good there is often a delay.

Hump and repeater signals are not usable for this purpose since they apply only to movements of the hump engine.

Transmission of Way Bills to Yard Office

Usually the yard office is located at some point close to the hump. If the conductor of the arriving train rides the head end at the time the train arrives, he can deliver the way bills to the yard office in person. If the conductor rides the rear end of the train, messenger or other transmission service of some sort may be provided to prevent delay.

Where highways parallel the yard, messengers on motorcycles are sometimes employed to deliver the way bills to the yard office.

Where the entrance end of the receiving yard is not accessible to highways, pneumatic tubes may be provided for transmitting way bills to the yard office.

Inspection

Instructions as to inspection, when necessary, are given by telephone to the inspectors' headquarters. After a train has been inspected, the yard office and hump office are notified by telephone that the train is ready for humping.

Transmission of Lists to Hump and Retarder Operators

Lists of cars to be humped showing the car number and the track number to which the car should be switched are prepared in the yard office for each train and are sent to the hump and retarder operators. In retarder equipped yards, and sometimes in other hump yards, additional information is provided, such as car initial, the kind of car, the kind of load, the approximate weight, etc.

If the yard office is close to the hump, messenger service may be used, but in general more efficient facilities are required.

Teletype machines, located at the hump and in each of the retarder towers, permit typing the list simultaneously at each of the locations as well as in the yard office.

In some cases lists are transmitted to hump foreman and operators by means of pneumatic tubes.

Moving Train From Receiving Yard to Hump

Where special facilities for continuous communication with the hump engine are not provided, the hump crew is given instructions before it leaves the hump as to which train to move from the receiving yard. The crew lines its own route and in some cases, where traffic is not heavy, lines the route from the receiving yard track to the hump before going around the train.

When traffic is heavy, a switchtender is assigned to the switching area between the receiving yard and the hump, and instructions are given to him either by the hump locomotive crew as they pass, by telephone, or in some cases by loud speaker. In some yards this switching area is equipped with power switches and operated from a control at the hump.

Frequently conditions change after the hump locomotive has left the hump, thus requiring a change in instructions to the hump locomotive crew. In many yards this cannot be done, because facilities are not available for communication with the hump locomotive crew until it has returned to the hump.

Where horns or whistles can be used without confusion the crew may be signaled to go to a field telephone. Loud speakers located in the field may also be used for giving instructions directly to the crew, but there is no acknowledgment.

When the hump locomotive is equipped with the two-way locomotive communication system, instructions can be given and acknowledged immediately.

Constant communication must be maintained with the hump locomotive crew when the train is being moved toward the hump. Wayside signals located at the hump and at other points in the receiving yard are generally used to instruct the engineman whether he is to hump at fast, medium or slow speed, or whether he is to stop or back up.

In foggy weather it is difficult to see the wayside signals and, therefore, they are sometimes supplemented by horns or whistles. Horns or whistles may cause confusion, especially where more than one is required in the area, and consequently other means of communication are desirable.

Cab signals provide a positive indication in the cab, which can be recognized regardless of weather conditions.

The locomotive communication system may be used for directing the movement of cars toward the hump. It serves very well in regulating the humping speed, since the hump foreman is not restricted to the use of one of three speeds, as may be the case with wayside or cab signals. One-way communication is used for this purpose. Acknowledgment is evident by the movement of the train and further acknowledgment can be given by blowing the locomotive whistle.

Wayside signals should be used at the hump, regardless of other communication systems in use, since frequently it is necessary to make movements over the hump with engines not equipped with communication facilities.

Humping

Loud speakers are used in the hump office and each of the car retarder towers, since it is very important to have direct communication between the hump and the retarder operators. Conditions existing in the classification yard can be reported by the operators to the hump foreman. Also the hump foreman can instruct the operators as to changes in the location of classifications in the yard, as well as changes in the lists which occasionally are necessary due to bad-order cars. When poor-running cars block the leads, or when it is necessary to place cars on tracks where they do not belong, the information is reported to the hump foreman, so that instructions for correction can be given to the hump crew.

Trimming

It is frequently necessary for the hump engine to go into the classification yard to couple cars and shove them to the far end of the classification tracks. It has also to pick up cars which may have been switched into a track where they do not belong, to set them over into tracks where they do belong.

Where special facilities are not available, it is customary to instruct the hump engine crew before leaving the hump as to what moves should be made, and this work is carried out as instructed before the engine returns to the hump. Frequently it is necessary to change the instructions, and the necessity of waiting for the engine to return to the hump to be advised of the changes causes unnecessary work and delay.

A wayside signal located near the hump and facing the classification yard is often used as a trimming signal. Its aspects govern the movement of locomotives through the switching area between the hump and the classification tracks. The trimming signal is sometimes interlocked with the hump signal, so that cars will not be humped in error, while a locomotive is engaged in trimming.

Horns or whistles are sometimes located in the classification yard to call the conductor of the hump crew to a field telephone for a change in instructions.

At other locations, loud speakers are located in the classification yard for the purpose of changing instructions to the crew by one-way communication. However, there is no acknowledgment, so that uncertainty exists until a check can be made when the crew returns.

Where the locomotive communication system is available, changes in instructions are made by direct conference with the conductor or engineman, thus saving a considerable amount of time. Two-way communication provides for best efficiency, since frequently information which can be furnished by the crew in the yard alters the instructions which might otherwise be issued in error.

Make-up of Trains for Departure

Instructions to the crew are usually given by messenger or directly to the conductor when he reports at the yard office.

Field telephones conveniently located serve to reduce delay when there is a question to be asked by the conductor. Horns or whistles (when they do not cause confusion) can be used to call a conductor to the telephone.

Transmission of Way Bills for Departing Trains

Way bills for departing trains must be delivered to the conductor, who usually boards his train at some distance from the yard office. Consequently, some means for transporting them are necessary.

Where highway facilities are convenient, a messenger with a motorcycle or automobile may be used for delivering the way bills to an office at the departure tracks, where they are handed to the conductor.

Where highway facilities are poor, pneumatic tubes from the yard office to an office at the departure yard may be used for transmitting way bills.

Dispatching of Trains

After the road locomotive is coupled to its train and ready to leave, authority must be given for the movement of the train from the yard. Such authority may be transmitted by telephone, loud speaker or signal indication.

Report on Assignment 7

Modernization of Passenger Terminals

H. L. Ripley (chairman, subcommittee), J. R. W. Ambrose, C. E. Armstrong, J. E. Armstrong, C. J. Astrue, H. Austill, A. L. Becker, W. J. Bedell, H. F. Burch, W. F. Cummings, H. G. Dalton, F. T. Darrow, M. H. Dick, R. J. Hammond, J. M. Hood, E. T. Johnston, J. S. Knight, H. C. Lorenz, C. A. Mitchell, C. H. Mottier, W. B. Rudd, W. C. Sadler, E. E. R. Tratman, V. R. Walling, R. W. Willis.

Your committee submits the following report of progress in connection with the modernization of passenger terminals, a new subject assigned to the Yards and Terminals Committee for the year 1941, with recommendation that the subject be continued.

The conclusions are shown as tentative and are now offered for consideration and study with the expectation of offering them, as written or as modified, for adoption at the next annual meeting.

Introduction

As the first contact the average patron has with a railroad is at the passenger station, the first impression made upon him depends upon the appearance of the station itself, of the grounds surrounding it, and upon the comfort, convenience, and attractiveness of the layout and appointments that he finds after he enters; and also upon the character of service he receives from the personnel, interested and friendly or cold and formal, even before he boards his train.

All this is especially true of the casual passenger who uses the train infrequently, but then often for long distances, and is unfamiliar with the station routine and needs guidance in a pleasant but unobtrusive way which is the essence of politeness. This makes the matter of modern conveniences and appointments of particular importance.

The subject assigned to the committee is confined to "Terminals," and the phase of the matter selected for this report is confined, generally, to stations and their appurtenances where trains originate or terminate their trip or where cars are picked up or dropped, coming from or going to some other route. However, some of the precepts set forth might be applied to other stations as well.

Directional Information

Many of our terminals are seriously lacking in proper directional information to guide the passenger using the station. It is a peculiar trait of human nature that people generally dislike to request strangers to direct them to the point to which they want to go.

An information booth in the concourse or main waiting room is a regular and necessary feature, in most large stations, but that alone is not enough to guide the traveler. Signs pointing to the various platforms, exits, stairways, ticket office, baggage room, parcel room, waiting room and other facilities appurtenant to a large station, should be provided, properly located, and conspicuously and copiously posted, keeping clearly in mind that many passengers are strangers, while not a few are unaccustomed to traveling and are easily confused. This is particularly important when the station and tracks occupy different levels and use is made of various corridors, often winding.

While the directional signs should be conspicuous, they should not be glaring or gaudy. Such an effect should be studiously avoided. They are not advertising billboards and they can and should be made attractive as well as easy to see and clearly informative. A sign which a passenger going in the wrong direction has missed, inadvertently,

is no longer of help to him. Another sign a little farther along will turn him back and send him in the right direction without having to make inquiry.

Track and Platform Length

One of the principal requirements today is greater length of tracks and platforms to accommodate the longer trains now in general use. Frequently this is the most difficult part of the problem, especially at stub-end stations; but in this connection each point is an individual problem and your committee knows of no general rules that can be cited or principles stated that would not be obvious and so unwarranted in this report.

Signals

Where track changes are involved, generally, changes in signals are involved also and they must be studied simultaneously with the construction problems.

Fire Protection

Fire hazards and better fire protection should be studied, and under some conditions, perhaps, sprinklers should be installed.

Good Housekeeping

Nothing can take the place of and do as much for the appearance of a terminal as cleanliness and good housekeeping. Here little things count.

Changed Transportation Characteristics

In the past, up to about 1920, transportation by rail increased rapidly, and the major endeavor was to keep up with the increasing demand, quantitatively, without giving too much attention to improvement in the quality of the service rendered.

Beginning about 1920 this growth in *quantity* of service began to decline and the practices of the past in extensive construction, like building new lines and more monumental stations was reversed and improved service began to take the major place in the field. Thus faster trains, better equipped, and more convenient and more attractive service, both while on the move and at the station, became an accepted expectation of the traveling public.

This change took place in connection with both freight and passenger transportation, both caused in larger measure by improvement of gasoline-driven vehicles and of the highways over which they operate. It does no good to feel sorry for ourselves—we must hunt out ways and means to give the traveler what he thinks he wants and likes or he won't come back to the rails.

Changed Passenger Habits

The whole trend of passenger habit of travel has changed in the last 20 or 25 years and the requirements for the service have changed likewise; and railroads, if they hope to turn the trend that has been running sharply against them, must change with them. This calls for an even higher degree of engineering skill and more ingenuity than did the old *extensive* planning of the past. Moreover, we need not only to meet the condition, but we must tell about it in such a persuasive way as to be convincing if we expect to be effective, and objective realism must be used instead of complaining and wishful thinking in attempting to meet the problem.

This report, as before stated, is confined to the effect that such changed habits and conditions may have on the requirements at passenger terminals and as to the manner in which these changes have been and can be met to fit into the requirements of the community and the service, through revisions and improvements where such changes

have become desirable and are not unduly costly. These changes may affect layouts, track arrangements, service facilities and the like, as they have existed in the past, without abandonment or relatively complete reconstruction at a cost that would be prohibitive. Perhaps this can be illustrated better by example than by theorizing alone. Ostentation should be avoided as costly and undesirable.

Modern inventions and refinements have accustomed prospective passengers to comforts, conveniences and even what were formerly considered luxuries that they did not expect in the past, in their homes, in stores where they trade, in hotels where they stop, and in their travel requirements. This makes them impatient with inconveniences and delays, and railroads must be alive to the new demands in order to meet the competition, not losing sight of economic considerations that should control in each individual case.

Baggage, Mail, Express, Etc.

Facilities for handling baggage, mail and express should be planned carefully. Separate avenues for handling these auxiliary services will greatly expedite all classes of traffic.

Taxis and Autos

Taxis and private automobiles are now the means used generally for reaching and departing from the stations. This means less time is needed to get to and from the station and enables a patron to meet a train with more assurance and closer timing, but it adds a new demand for adequate parking space for both taxis and private automobiles, either on the station grounds or immediately adjacent to them as supplementary accommodations. Again, while this reduces the waiting time in the station itself, coming or going, and less use is made in many instances of such auxiliaries as the waiting room and baggage room, it requires better but not necessarily larger facilities at many points.

The Waiting Room

Modern seating equipment such as chairs, couches and a few tables substituted in place of the old stiff benches, with perhaps benches along the walls to take care of an overflow caused by weather or other emergencies, adds to the attractiveness of the waiting room at relatively small cost. Frequently, following the modern trend, where formerly two waiting rooms were provided, one for men and one for women, they can be combined into one, and the space saved is put to better use; but a separate and secluded "rest room" for women is a necessity at all large stations.

Ticket Counter

Attention might well be given to improvement of the ticket window. Formerly small barred openings, not much larger than handholes, were the rule, often without even a shelf for setting down a handbag. The modern ticket office provides large windows which give a more open view and a more friendly aspect to the transaction between the ticket seller and the patron. In some instances an open counter has been substituted for the grilled window. In other cases these counters have sectional partitions closing them by roller curtains. In all cases provision should be made for protection of the money and the ticket stock.

Painting and Lighting

Frequently a change in the lighting in connection with an attractive color scheme for the inside finish, such as the substitution of modern lighting, combined with atten-

tion to cleaning, will alter and greatly improve the whole appearance of a station at relatively small cost. Larger windows and modern fixtures properly located are a means to this end.

Toilet Facilities

Better attention to and modernization of toilet facilities and the substitution of sanitary walls and flooring, invite cleanliness. Providing pay toilets, substituted for some of the open toilets, often with a reduction of space used, will effect the same result. This means not alone modern fixtures but clean and attractive surroundings as well, easily accessible and well designed, with a proper retiring room for women patrons. These facilities can be made not only an incentive to "travel by train" but a source of revenue as well.

Combined Service

Sometimes rail and bus terminals may be combined to the advantage of both services. This may affect requirements such as restaurant service, ticket counters, toilet service, baggage handling facilities, and the like.

Heating

Modern heating often results in less cost as well as improved service and, in the north at least, the substitution of a tight partition between the concourse and the train shed in place of open fence and gates will still objections to the existing layout and permit the utilization of the concourse, in part, as an adjunct to the waiting room, at relatively small expense. Many passengers prefer to wait where they can see the train, if they can do so under comfortable conditions.

Environment

In modernizing terminal station buildings careful attention should be paid to the character of the country where they are located and the prevailing mode of architecture in the vicinity. The mission type so prevalent in the southwest fits that country but would be out of place in New England, just as the Old English type would look out of character in the southwest. Careful attention should be given to the surroundings and to the landscaping of the grounds, to insure that they, too, fit the climatic and geographical conditions.

Many of the older terminals were built during the so-called Victorian era and have heavy overhangs and copings with elaborate ornamentation inside and out. The modern trend to simple lines makes these buildings look gaudy and unsightly, particularly so where maintenance has been curtailed. Frequently, considerable savings can be made by removing this old trim and substituting a simpler and more pleasing finish, more in keeping with the times. The Pennsylvania Railroad Station at Trenton, N. J., is a good example of such treatment.

Vertical Distances

Where considerable vertical distances are to be overcome and large numbers of passengers need to be handled quickly, moving stairs are a very definite aid and a decided convenience, especially to the old or infirm. Ramps in place of stairs serve the same purpose, but they require longer horizontal distances to overcome the given vertical distances.

Barriers

Where turnstiles or other barriers are involved, at times it is desirable and advisable to introduce an electric eye to open and close the barrier as this speeds up the movement of travel in one direction and is an appreciable convenience to passengers carrying hand baggage.

South Station, Boston, Mass.

The South Station, Boston, Mass., is a notable case in point of an old station brought up to date.

This station was opened in 1899, 42 years ago. Fortunately the basic design was good—surprisingly so for so old a structure. The concourse, fanning out as it does towards the main entrance, lends itself admirably to the handling of large crowds without confusion or congestion.

The layout consisted of a stub-end, head-in station, having 28 tracks originally, with separate baggage platforms between tracks used for long distance trains and separate baggage rooms for inbound and outbound service. Extensive toilet, smoking room, office space, and other incidental facilities located on the main floor, could just as well be somewhere else, instead of taking up space that could be better used.

The baggage platforms were too narrow for two trucks to pass, so most of the baggage was handled on the passenger platforms, interfering with the movement of passengers as these platforms also were narrow for combined service.

The train shed was of the old balloon type, costly to maintain and dreary to contemplate. The steel work was badly corroded and required reconstruction. The platforms were of wood and required complete rebuilding.

The great, balloon type train shed with its long unsightly trusses and its intermediate columns was removed. This allowed the removal of the narrow baggage platforms and the respacing of passenger tracks, with combined platforms now of ample width between alternate pairs of tracks and low shelter sheds of modern type. This, in turn, did away to a large extent with the smoke and gas that was disagreeable in the old balloon shed and drifted into the concourse. All this was done for an outlay that was definitely less than cost of replacing the old construction and produced far better results.

A baggage subway at the outer end of the train shed was extended to cover all the long distance service tracks and was connected with the platforms by ramps in place of the old baggage lifts. The wooden platforms were replaced by concrete and were lengthened to accommodate the longer trains.

The layout was faulty in that it invited the use of the concourse as a passway for morning and evening crowds, amounting to 10,000 persons a day, going to and from the industries located just across the bridge at South Boston. These persons did no business with the railroad but simply used the 700-ft. concourse as a convenience; it being cooler in summer and warmer in winter than the parallel sidewalk outside on Summer Street. This non-passenger traffic occurred at just the times when the concourse was most in use by arriving and departing passengers, amounting at rush periods to more than 1,000 a minute.

The carriage facilities were at the wrong end of the concourse and were little used for that reason. Because of the falling off of passenger travel, and especially commuter travel, one of the outside ramps to the lower level was no longer needed. Filled in, it makes an admirable stand and approach for taxis at the midpoint of the concourse, with a separate entrance covered from the weather.

The old porte cochère and carriage entrance, little used because of its location, was closed and turned into a picture theater to show current events, industrial pictures and other "shorts." This change closed the concourse to the non-passenger pedestrian interference and added another source of revenue, at relatively small expense, besides providing added convenience to waiting passengers.

The toilet fixtures were worn out and both they and the smoking room were obsolete, besides being an eyesore, a heavy expense and a source of embarrassment as they were gathering places for "bums," sober or otherwise, and it was impossible to keep the facilities clean. The smoking room was torn out and the toilets moved into the basement, modernized and furnished with modern plumbing and neat sanitary fittings. Coin-locked toilet rooms, dressing rooms and bath rooms were supplied and, while the cost was high, these improved facilities produce revenue, besides greatly adding to the comfort of the patrons.

The space formerly occupied by the smoking and toilet room was given over to improving, enlarging and modernizing the lunch room, and a connecting restaurant. The lunch room, as set up at present, has a seating capacity of 180 and the dining room seats 222. The dining room will take care of 285 without crowding and can accommodate 375 at long tables at a banquet. Both are served from the same kitchen and pantry.

Both rooms are well patronized throughout the day and both are filled at noon, as they open off the street as well as off the concourse, and are thus well situated and well suited to cater to outside patrons as well as to passengers and employees of the railroads. The station is located near the business center of the city and, as both the restaurant and lunch room are air conditioned, attractive and well managed, they not only bring in a large revenue to the terminal company but are also a convenience and a credit to the management of the terminal.

A ceiling with concealed lighting was installed over the concourse which formerly had been open to the roof and to the exposed supporting trusses, and was barnlike, dirty and unattractive. Partitions with sliding doors were substituted for the open grill, with door openings opposite the platforms, and enough heat was supplied to make the concourse, now free of smoke and fog, warm enough in winter to be comfortable for passengers wearing coats. This, in turn, made it feasible to install attractive and well patronized booths for the sale of commodities, again a source of substantial revenue as well as a convenience to passengers.

A change in the habits of passengers made it feasible to do away with one of the baggage room buildings that had been little used in recent years. The space was sold to the U. S. Government for a large branch post office at a price sufficient to cover the major part of the improvements outside of the train shed, which later would have had to be rebuilt anyway and was a separate problem.

The Boston Terminal South Station was planned in the middle "Nineties" and completed in the late "Nineties", but it would be hard for one using it now to believe it was not a modern layout, up-to-date and recently designed. There is still opportunity for improvement in the waiting room by the substitution of modern furniture and better lighting, without any other structural changes.

The greatest present defect at South Station is the absence of passageways for foot passengers to cross to the opposite sidewalks under the two principal and much used streets, which most of the foot passengers have to cross at grade. As such passways were not provided in the original layout it is now too late, because the streets are filled with pipes, conduits, drainage facilities and the like. This matter of passways, over or undergrade, to the opposite sidewalks should be given careful consideration in designing new layouts and in remodeling old ones. Frequently, in connection with original construction,

and often in major changes, the municipality joins in the project and improvements are made in the surrounding street approaches. Obviously the matter of crossings for foot passengers, safely and expeditiously, would come within the scope of such participation. Such an improvement at Chicago is noted below.

Another hindrance at South Station that seems to be beyond remedy at any reasonable cost is lack of off-street parking space for waiting automobiles. This matter, too, should have the attention of the engineers when terminals are undergoing study for modernization.

Chicago & North Western—Chicago

At the Chicago & North Western Terminal, an overhead station at Madison and Canal streets, Chicago, the railroad experienced some of the same difficulties as at Boston. It was able to remedy the situation as to foot passenger crossings, in part, by opening a corridor through the Daily News Building, with a footbridge over Canal street at second story or platform level. A part of the lower or street level space, previously but little used, was given over to a restaurant, cafeteria, barber shop and pay toilets, to the advantage of the railroad and its passengers.

The train shed here is of the Bush type with a low concrete roof having smoke vents over the center of the tracks and the smoke stacks. The vertical clearances were close and when larger locomotives were put into service these close clearances had to be revised. The vertical side walls and the braces across the vents had to be torn down and rebuilt in part. This is something to watch for when this type of shed is used.

Union Pacific, Cheyenne, Wyo.

The Cheyenne station of the Union Pacific has been modernized. A much needed improvement in handling its passengers was made by building an enclosed concourse between the station proper and the tracks, by building a subway under the tracks from the new concourse to the various platforms and by providing a canopy roof of the butterfly type over each platform to protect passengers entering or leaving the trains.

Milwaukee Station, Minneapolis, Minn.

Another notable job of modernization of a terminal without extensive and expensive structural changes is that developed at the Milwaukee station at Minneapolis. This station was completed in 1898 and conformed to the ideas of propriety that prevailed at that period. Like South Station, Boston, built at the same time, it was a stub-end station with a concourse that was open at the outer end to the weather and to the entrance of smoke and soot. It was also open to the roof.

No fundamental changes were made in the basic structure itself insofar as the substructure and outer walls were concerned, nor were any necessary as the contained area was sufficient to meet the needs of the three roads using the terminal, and the outside appearance was good. The whole tone of the structure was changed, however, by doing away with the massive, dark type of finish and appointments of that earlier era and the substitution of open spaces and light appointments in their place.

The interior was rearranged by pulling out interior walls, opening up enclosures to the light and moving the ticket office out into the waiting room and placing it at the middle point of the walled space that separated the waiting room from the main concourse, substituting wide ticket windows for the narrow grills, thus giving it a more friendly appearance, and placing it on the direct line of travel from the two street entrances to the concourse and tracks, with a wide passway for passengers to go and come at each side of the ticket counter.

The concourse, formerly open to the weather on the track side, was closed in and given a false ceiling. New lighting and sufficient heat was supplied to make it comfortable for waiting passengers.

The interior of the building was finished originally in yellow brick, terra cotta and dark wood trim and was gloomy and heavy in appearance. White enamel was applied to the ceiling and upper wall spaces, while the terra cotta trim was retained around the arch openings and where it would be pleasing and effective, thus lighting up the whole interior. Fluorescent lighting was substituted for the old drop lights, and chairs and lounge seats replaced the old wooden benches. Special attention was given to the women's retiring room to make it convenient and attractive.

A modern restaurant with modernistic color scheme took the place of the outmoded men's smoking room. It was fitted with a U-shaped counter at one side and tables at the other, thus adding to the serviceability as well as to the attractiveness of the layout as a whole.

General

Many other examples could be cited of revisions made or under way, but they would be largely repetitious of matter already covered.

A fundamental principle that should be kept clearly in mind at all times is that economic factors should never be overlooked in studying contemplated modernizing of passenger terminals, any more than elsewhere. Extravagance is no more warranted here than in other phases of the railroad problem, or in our social problems, or in our daily lives. The need should be considered first; then the extent to which it can be met, reasonably and under existing circumstances; then studies should be made to determine the detailed changes and the method of procedure to be followed in meeting the problem in a way to accomplish the greatest good with the money available; which money when so spent will not be available for improvements elsewhere.

Conclusions (Tentative)

1. Nothing can take the place of or do as much for a terminal as cleanliness and good housekeeping.

2. Longer tracks and platforms often are required to take care of the longer trains now in general use. This in turn requires careful attention to revised signaling.

3. Fire hazards should be considered and perhaps sprinklers should be provided at certain points.

4. Directional signs should be given particular attention. They should be displayed conspicuously, easy to see but not gaudy; and they should be repeated so that if a passenger going in the wrong direction misses one, another farther along will set him right. This is especially important where corridors are long and winding and different facilities are at different levels.

5. Taxis and private automobiles which have displaced horse-drawn vehicles and trolley cars, need parking space while waiting for trains, either on the station grounds or adjacent thereto.

6. Because of changes in habits and in facilities available for travel to and from terminals, less waiting time in the station is now the rule, but passengers expect better, though not necessarily bigger, accommodations—in the concourse, in the waiting room, when buying tickets or checking baggage, in the toilet facilities and in general service conveniences.

7. A single, combined, waiting room can be substituted to advantage for the old arrangement of two separate rooms, but a proper and attractive retiring room for women should be provided.

8. The old smoking room, which often was used largely as a loafing place for undesirables, may be abolished when extensive changes are made.

9. Generally, coin-locked pay toilets should be substituted for some of the former open toilets and, at the larger terminals at least, coin-locked dressing rooms and baths may be provided.

10. Rail and bus terminals can sometimes be combined with advantage to both services.

11. Substitution of modern heating, properly planned, often will result in a reduced cost for its operation and maintenance, as well as providing better service.

12. Substitution of a closed-in concourse, with a tight partition between it and the train shed in place of an open grill, with sufficient heat supplied to make the concourse comfortable for passengers in winter weather, is desirable and is becoming general, as it will permit use of the concourse as an adjunct to the waiting room. Many passengers prefer to wait where they can see the trains if they can do so without discomfort.

13. Substitution of modern furniture such as chairs, couches and a few tables in place of the old, stiff, straight-backed benches, and the substitution of modern lighting and attractive painting with due attention to the color scheme, will transform an old-type waiting room into a pleasing room at relatively small expense.

14. Improvement at the ticket counter by the substitution of larger openings for the former grilled windows or, at points where it is feasible to do so replacement of the windows and grills by an open counter, makes for a more friendly atmosphere. Provision for the protection of the money and the ticket stock should not be overlooked.

15. The character of the country and the prevailing type of architecture in the locality should have careful attention. If the present station is not in keeping with its surroundings, frequently it can be brought into harmony by careful study and minor structural changes at moderate cost. Sometimes the stripping off of elaborate cornices, fussy ornamentation and the like, will not only bring the structure into proper relation with its environment but will also reduce maintenance expense enough to make the change profitable in itself.

16. Moving stairs aid in overcoming considerable vertical distances, aid in handling passengers quickly, and are a convenience, particularly to the old or infirm. Ramps in place of stairs, to a considerable extent, tend to serve the same purpose where room is available.

17. Balloon train sheds are definitely a thing of the past. Umbrella, butterfly or other modern type of platform shelter should be substituted where practicable when major changes are to be made.

18. Care should be taken to make it inconvenient for non-passengers to use the concourse and passways as a thoroughfare, thus interfering with patrons of the railroads.

19. Passageways, over or under adjoining streets to the opposite sidewalks, should be provided where feasible, through proper cooperation between public authority and the railroad.

20. Economic considerations should never be lost sight of in studying improvements contemplated in connection with a passenger terminal.

Report on Assignment 8

Bibliography on Subjects Pertaining to Yards and Terminals Appearing in Current Periodicals

E. E. R. Tratman (chairman, subcommittee), M. H. Dick, W. C. Sadler.

General

Agreements—Air right developments and lease—AREA, Proceedings, 1941, p. 819.

Agreements—Pipe-line crossing of railroad—AREA, Proceedings, 1941, p. 832.

Agreements—Unloading liquefied petroleum gas and other gases—AREA, Proceedings, 1941, pp. 41, 820.

Brine—Damage to track and structures; means of prevention—AREA, Proceedings, 1941, p. 628.

Buildings—Inspection, maintenance, heating and fire protection—American Railway Bridge & Building Association, Proceedings, 1940, pp. 135, 167—Railway Age, 1940, p. 637—AREA, Proceedings, 1941, pp. 106, 822.

Buildings—Modernizing and deferred maintenance—Railway Engineering and Maintenance, 1941, February, p. 84; November, p. 797—American Railway Bridge and Building Association, Proceedings, 1941.

Buildings—Termite attacks and prevention—American Railway Bridge and Building Association, Proceedings, 1940, p. 167—Railway Engineering and Maintenance, 1940, November, p. 763—Railway Age, 1940, November 2, p. 640.

Clearances—Loading gages on English railways; methods of testing. Also methods of calculating clearances of cars at turnouts and curves; and consideration of clearance in design of structures—Journal of Permanent Way Institution (England), 1941, Vol. 59, April, part 1, p. 59.

Clearances—Third-rail and overhead wire conductors—Electrical Section, AAR, Proceedings, 1940—Railway Age, 1940, November 9, p. 678—AREA, Proceedings, 1941; p. 30.

Coordinated Traffic—Atlantic & St. Andrews Bay; bus and truck service—Railway Age, 1941, April 26, p. 726.

Coordinated Traffic—Baltimore & Ohio; railway operates pick-up and delivery truck service—Railway Age, 1940, December 28, p. 988.

Coordinated Traffic—Chesapeake & Ohio; freight cars and motor trucks handle L.C.L. business—Railway Age, 1941, May 17, p. 850.

Coordinated Traffic—Chicago, Burlington & Quincy; in Chicago–Kansas City service, motor trucks and trailers handled on flat cars for door-to-door service—Railway Age, 1941, February 8, p. 295.

Coordinated Traffic—Denver & Rio Grande Western; truck service—Railway Age, 1941, February 22, p. 352.

Coordinated Traffic—Dominion–Atlantic; trucks substituted for local freight—Railway Age, 1941, March 22, p. 530.

Coordinated Traffic—English railways; service and financial problems—Railway Gazette (London), 1941, April 18, pp. 439, 447.

Coordinated Traffic—Erie; demountable 3000-gal. tanks of milk carried on flat cars to Jersey City to be hauled on trailers to a Brooklyn dairy company—Railway Age, 1940, October 26, p. 602.

Coordinated Traffic—Great Northern; truck routes in Montana expedite service—Railway Age, 1940, October 26, p. 595.

Coordinated Traffic—Gulf, Mobile & Northern; truck and trailer service operated for short haul and local service on 1700 miles paralleling its tracks—Railway Age, 1941, September 27, p. 494.

Coordinated Traffic—Illinois Central; truck lines proposed to relieve cars for defense purposes and to expedite local service—Railway Age, 1941, August 23, p. 318.

Coordinated Traffic—New York & Long Branch; bus service introduced to reduce stops of through trains—Railway Age, 1941, May 31, p. 985.

Coordinated Traffic—New York Central; milk traffic handled by 4,000-gal. tanks on flat cars—Railway Age, 1941, April 5, p. 604.

Coordinated Traffic—Northern Pacific; truck and bus service in Montana—Railway Age, 1940, November 23, p. 801.

Coordinated Traffic—Southern Pacific; motor truck feeder service introduced as cheaper than building branch lines—Railway Age, 1940, November 23, p. 803.

Coordinated Traffic—Railways given permission to operate truck service—Railway Age, 1941, March 22, p. 531.

Coordinated Traffic—Railways slow to prevent diversion of produce traffic to trucking concerns; railway company markets often unsatisfactory—Railway Age, 1940, November 30, p. 827.

Coordinated Traffic—Railway terminal facilities for handling motor trucks and trailers on and off cars—AREA, Proceedings, 1941, p. 136.

Coordinated Traffic—Review of bus and truck coordination with train service on various railways—Railway Age, 1941, January 4, p. 114; May 24, p. 946; June 28, p. 1188; July 26, pp. 165, 167.

Fire Protection—Buildings and Bridges—AREA, Proceedings, 1941, pp. 106, 822.

Pipe Line Crossings—Agreement for piping gases and specifications for piping non-inflammable substances—AREA, Proceedings, 1941, pp. 555, 820, 832.

Platforms and Floors—Paving for platforms, driveways and floors—American Railway Bridge and Building Association, Proceedings, 1941—Railway Engineering and Maintenance, 1941, November, p. 800.

Siding—Definitions for sidings and passing tracks—AREA, Proceedings, 1941, pp. 108, 854.

Snow—Chicago, Milwaukee, St. Paul & Pacific; motor truck handling of snow at terminals—Railway Engineering and Maintenance, 1940, December, pp. 817, 829; 1941, January, p. 37.

Snow—Equipment, methods and organization for handling ice and snow at terminals—Roadmasters Association, Proceedings, 1940—Railway Age, 1940, September 28, p. 443.

Stopping Trains—Costs involved—Signal Section, AAR, Proceedings, 1940, and 1941; Vol. 37, No. 2, p. 548; Vol. 38, No. 1, p. 6—AREA, Proceedings, 1941, pp. 31, 803, 804.

Stopping Trains—Diagram of cost; H. E. Niksch, Chicago, Milwaukee, St. Paul & Pacific—Railway Age, 1940, November 23, p. 799.

Track—Mechanical facing-point locks for spring switches—Signal Section, AAR, 1940, Vol. 37, No. 2, pp. 561, 617.

Track—Signal protection for turnouts having spring switches—Signal Section, AAR, 1941, Vol. 38, No. 1, p. 258.

Track—Switch heaters; equipment required—AREA, Proceedings, 1941, p. 29—Railway Engineering and Maintenance, 1941; January, p. 29—Electrical Section, Engineering Division, AAR, Proceedings, 1940.

Track—Switch lamps; economy of electric lights—AREA, Proceedings, 1941, p. 32—Railway Engineering and Maintenance, 1941, April, p. 287.

Track—Switch lamps and reflector units as substitutes. State laws as to switch lamps—AREA, Proceedings, 1941, p. 606—Signal Section, AAR, 1941, Vol. 38, No. 1, p. 15.

Track—Switch layouts; switches, frogs and crossings; standard plans—AREA, Proceedings, 1940, p. 595—Signal Section, AAR, 1940, Vol. 37, No. 2.

Track—Turnouts; changes in signaling for fast trains—Railway Age, 1941, January 18, p. 175.

Train-Hour—Various factors entering into train-hour cost—Signal Section, AAR, 1941, Vol. 38, No. 1, p. 20.

Train-Resistance—Train resistance of freight trains—AREA, Proceedings, 1941, p. 69.

Passenger Stations and Terminals

Boston—Boston & Maine, North Station; handling heavy American Legion traffic—Railway Age, 1940, November 9, p. 672.

Brisbane—Queensland Government Railways; new Roma St. station relieves Central Station from congestion due to suburban traffic—Railway Gazette (London), 1941, July 18, p. 54.

Brussels—Belgian State Railways; new South Station and rigid-frame welded approach viaduct—Engineering News-Record, 1941, July 31, p. 60.

Chicago—Chicago, Burlington & Quincy opens new ticket office—Railway Age, 1941, December 7, p. 879.

Chicago—Chicago, Rock Island & Pacific; suburban station built of brick—Railway Engineering and Maintenance, 1941, July, p. 476.

Chicago—Illinois Central; terminal division has private telephone exchange—Railway Signaling, 1941, September, p. 473.

Chicago—Illinois Central; washing exterior of terminal station building—Railway Engineering and Maintenance, 1941, August, p. 541.

Chicago—Rapid-transit subway stations; island and side platforms—Journal of Western Society of Engineers, 1938, December, pp. 289, 300; 1941, April, pp. 62, 67.

Chicago—Suburban service on main-line railways and rapid-transit lines—Journal of Western Society of Engineers, 1938, December, p. 296.

Durango—Mexican National Railways (picture only)—Railway Age, 1941, January 4, p. 51.

Hudson—New York Central; station reconstruction and modernizing—Railway Engineering and Maintenance, 1941, January, p. 30.

Hjorring—Danish State Railways; new station with rearrangement of tracks to replace two stations—Railway Gazette (London), 1941, August 29, p. 212.

La Crosse—Chicago, Burlington & Quincy; new station of modern design and interior finish—Railway Age, 1940, November, p. 674.

Lafayette—Wabash; modernized station 72 years old—Railway Age, 1941, March 1, p. 380.

London—London & Northeastern; centenary of Fenchurch Street terminal, 1841; originally on cable line; locomotive traction 1849; remodeled in 1935—The Engineer (London), 1941, August 8, p. 89—Railway Gazette (London), 1941, August 8, p. 127.

Los Angeles—Heavy traffic of transcontinental trains—Railway Age, 1940, October 5, p. 488.

Melbourne—Victoria Government Railways; revision of Flinders Street terminal—Railway Gazette (London), 1941, June 20, p. 675.

Melbourne—Victorian Government Railways; handling traffic on the suburban system. Paper read by J. M. Ashworth before Institution of Engineers of Australia—Railway Gazette (London), 1941, January 17, pp. 59, 62.

Memphis—Cars parked for convention served with electricity by oil-electric locomotives—AREA, Proceedings, 1941, p. 811.

Minneapolis—Union Station remodeled and modernized—Railway Age, 1941, January 11, p. 137—American Railway Bridge and Building Association, Proceedings, 1940.

Montreal—Canadian National; total cost of new terminal to January, 1941, $22,425,000, with $4,100,000 to be spent in 1941—Railway Age, 1941, June 21, p. 1132—Railway Gazette (London), 1941, June 6, p. 622; September 19, p. 278.

Montreal—Canadian Pacific; new skylight roof over concourse—Railway Age, 1941, January 25, p. 216.

New Orleans—Terminal 4-percent bonds backed by Southern Railway—Barron's Magazine, 1941, July 7.

New York—Baltimore & Ohio; bus transfer between Jersey City terminal and New York City—AREA, 1941, Bulletin No. 425, p. 13.

New York—Grand Central Station; "crossroads of a million lives",—Paper by A. W. Herdman, National Safety, 1941, August.

New York—Grand Central Station; history and development of the terminal, by W. J. Wilgus—American Society of Civil Engineers, Proceedings, 1940, October; discussion, December, January, February, 1941.

New York—Stations on 6th Avenue subway—Transit, 1941, February, p. 51.

Philadelphia—Reading R. R. trainshed (picture only)—Railway Age, 1940, September 21, p. 413.

Rigaud—Canadian Pacific; station 84 × 40 ft. designed for serving crowds of pilgrims to shrine at Rigaud, Quebec—Canadian Transportation, 1941, January, p. 15.

Rochester—Chicago & North Western; modernizing interior of station 50 years old—Railway Age, 1941, March 15, p. 458—Railway Engineering and Maintenance, 1941, April, p. 276.

Rome—Italian State Railway; 7-mile underground railway being built from "Termini" station to exhibition grounds; overhead wires—Railway Gazette (London), 1941, May 30, p. 599.

St. Louis—Union Station; replacing burned interlocking tower and handling trains with plant out of service—Railway Signaling, 1941, May, p. 239—Railway Age, 1940, August 3, p. 171.

Saskatoon—Canadian National; combined station and office building replaces old structure—Railway Age, 1941, February 1, p. 249.

Singapore—Interior view of station—Railway Gazette (London), 1941, August 29, p. 217.

South Shields—London & Northeastern; proposed passenger or vehicle tunnel under River Tyne to connect stations at South Shields and North Shields—Railway Gazette (London), 1941, July 25, p. 87.

Suffern—Erie; small modern station—Railway Engineering and Maintenance, 1941, September, p. 681.

Windsor—Michigan Central; revision of signaling and terminal facilities at Canadian end of Detroit River tunnel—Railway Age, 1940, December 21, p. 949—Railway Signaling, 1940, November.

Bus Station—Proposed New York terminal for both long and short haul busses—Railway Age, 1940, December 21, p. 965.

Bus Station—Station on 42d Street, New York, connects with 250 air-plane flights daily—Railway Age, 1941, January 11, p. 151.

Bus Station—Terminal at Windsor, Ontario, for interurban and suburban lines—Canadian Transportation, 1940, September, p. 475.

Coach Yards—Car washing machines—AREA, Proceedings, 1941, p. 134.

Coach Yards—Car washing procedure—Railway Mechanical Engineer, 1941, April, p. 150.

Coach Yards—Electrical and mechanical equipment—Pacific Railway Club, Proceedings, 1940, August.

Coach Yards—Electric lighting to facilitate cleaning stainless-steel cars at Miami—Railway Electrical Engineer, 1940, August.

Coach Yards—Servicing and conditioning Pullman cars—Railway Mechanical Engineer, 1941, April and June, pp. 150, 240.

Coach Yards—Terminal facilities for servicing streamline trains and air conditioning equipment on cars—AREA, Proceedings, 1941, pp. 110, 112, 134.

Escalators—Chicago rapid-transit subway—Journal of Western Society of Engineers, 1941, April, pp. 62, 67.

Escalators—London underground railways; 80 ft. vertical rise—Railway Gazette (London), 1941, July 4, p. 2.

Escalators—New York; 6th Avenue subway—Transit, 1941, February, p. 52.

Garages—At railway terminals and stations—AREA, Proceedings, 1941, pp. 225, 875.

Municipal Transportation—Studies of local and suburban traffic—Civil Engineering, 1941, June, p. 353.

Platforms—Welded steel frames for platform canopies at large stations on Belgian State Railways—Railway Gazette (London), 1940, November 22, p. 539.

Servicing Trains—Drinking water coolers in cars served by electric refrigerators—AREA, Proceedings, 1941, p. 28.

Servicing Trains—Icing passenger cars at stations by high-lift power truck—Railway Mechanical Engineer, 1941, August, p. 327—Railway Age, 1941, September 27, p. 498.

Stations—Attitude of staff to public—Railway Age, 1940, November 16, p. 767.

Stations—Improvement in relation to recapture of passenger traffic—Railway Age, 1941, January 4, p. 23.

Stations—Improving service on trains and at stations—AREA, Bulletin 425, 1941, June-July, p. 9.

Stations—Lighting by fluorescent light—American Railway Bridge and Building Association, Proceedings, 1940, p. 117.

Stations—Modernizing old stations, large and small—Railway Age, 1940, November 16 and 30, pp. 749, 830, 915; 1941, January 11, March 1 and 15, pp. 137, 380, 458—Railway Engineering and Maintenance, 1940, December, p. 822; 1941, June, pp. 406, 425; November, p. 797—American Railway Bridge and Building Association, Proceedings, 1940 and 1941—New York Railroad Club, Proceedings, 1940.

Stations—Relative merits of wood, tile, brick, concrete, etc., for small stations—Railway Engineering and Maintenance, 1941, May and November.

Stations—Mass transportation; examples of heavy traffic at stations—Railway Age, 1940, November 16, p. 717.
Stations—Ticket offices not as modern as the trains—Railway Age, 1941, December 7, pp. 873, 879.
Suburban Service—Chicago; proposed coordination of steam railway suburban service with rapid-transit lines—Journal, Western Society of Engineers, 1938, December, p. 296.
Suburban Service—English railways stop main-line trains at London suburban stations where passengers can change to rapid-transit lines—Railway Gazette (London), 1941, July 4, p. 2.

Freight Stations, Terminals and Yards

Car-Load Freight—I.C.C. report on charges for loading and unloading—Railway Age, 1940, November 2 and December 21, pp. 652, 928.
Car-Load Freight—Multiple loading recommended by AAR to fill cars to capacity—Railway Age, 1941, August 23, p. 327.
Car Loading—Device to insure package freight is properly stowed and braced—Railway Age, 1941, July 12, p. 12.
Car Retarders—De Coursey Yard, Louisville & Nashville—Railway Signaling, 1941, January and February, pp. 22, 75—Railway Age, 1941, January 4, p. 27; March 29, p. 533.
Car Retarders—Economic value—Signal Section, AAR, Proceedings, 1940, Vol. 37, No. 2, pp. 551, 560, 616—AREA, Proceedings, 1941, p. 803.
Classification Yards—Use of classification tracks as departure tracks—AREA, Proceedings, 1941, pp. 108, 133, 856.
Classification Yards—English government organizes press visits to yards to explain railway work in war time—Railway Gazette (London), 1941, August, p. 181.
Classification Yards—German Government Railway Company; hump yards with Frolich or Thyssen hydraulic car-retarders—The Engineer (London), 1940, December 20, p. 392—Railway Gazette (London), 1940, September 6, p. 259; 1941, February 21, p. 206.
Coal Tipple—At Bienfair, Canada, with box-car loaders—Coal Age, 1941, January, p. 60.
Door-to-Door—Collect and delivery. (See "Coordinated Transport").
Express—Railway Express Agency; New York sorting station with sawtooth platform for trucks—Railway Age, 1940, December 14, p. 897.
Freight Facilities—Pennsylvania R.R. improvements at New York in 1940 about $3,650,000—Railway Age, 1941, July 19, p. 129.
Freight Forwarders—Proposed control by I.C.C.—Railway Age, 1941, January 11, February 22, March 8, 22, 29, April 12; pp. 147, 362, 431, 534, 590, 668.
Freight House—Canada Steamship Lines; new Montreal terminal has tailboard space for 100 trucks—Canadian Transportation, 1941, February, p. 97.
Freight House—Erie R.R.; new design at Edgewater, N. J.—Railway Age, 1940, November 23, p. 791.
Grain Elevators—Erie R.R., at Jersey City, burned in May—Railway Age, 1941, June 7, p. 1024.
Grain Elevators—Storage capacity and movement of wheat crop—Railway Age, 1941, June 14, July 5, 37, August 2, 9; pp. 1061, 37, 113, 205, 242—Canadian Transportation, 1941, September, p. 526.
Grain Handling—Methods on railways of Argentina—Railway Gazette (London), 1940, November 29, December 6, pp. 571, 592.
L.C.L. Freight—Chesapeake & Ohio handles this by cars and motor trucks—Railway Age, 1941, May 17, p. 850.
Oil Sidings—Rules for bonding rails of sidings—Signal Section, AAR, Proceedings, 1941, Vol. 38, No. 1, p. 120.
Package Car Loading—Better and faster service—Railway Age, 1941, January 4, 18, pp. 19, 193.
Perishable Freight—Refrigerator car traffic in California—Railway Age, 1940, December 28, p. 985—Association of Railroad Superintendents, Proceedings, 1940.
Platforms—Kinds of wood for outdoor platforms—Railway Engineering and Maintenance; 1941, May, p. 348.

Produce Terminals—Kansas City, Kan.; concrete pumped for buildings—Concrete Highways, Bulletin of Portland Cement Association, 1941, March–April.

Produce Terminals—Kansas City, Kan.; court forbids inducing dealers to come from Kansas City, Mo., to occupy new terminal—Railway Age, 1941, June 7.

Produce Terminals—Minneapolis, Minn.; Chicago, Rock Island & Pacific modernizes freight house for produce business—Railway Age, 1941, March 22, p. 516.

Produce Terminals—Coolers used in large fruit terminal—Refrigerating Engineer, 1941, February, p. 123.

Produce Terminals—Costs of truck and trailer hauling—Railway Age, 1940, October 12, p. 515.

Produce Terminals—Economical and critical study by A. C. Hoffman in "Large Scale Organization in the Food Industries," Monograph No. 35, U. S. Department of Agriculture—Railway Age, 1941, March 8, p. 437.

Scales—Specifications for track scales and for hand-operated grain-hopper scales—AREA, Proceedings, 1941, pp. 109, 115.

Sidetracks—Concreted tracks in street paving; Chicago, St. Paul, Minneapolis & Omaha—Concrete for Railways, Bulletin of Portland Cement Association, Vol. 5, No. 1, p. 10.

Stockyards—Status of stockyard companies as common carriers—Railway Age, 1940, November 9, p. 688; 1941, May 17, p. 857; August 9 and 16, pp. 245, 288.

Switching Locomotives—American Locomotive Co.; oil-electric; 100 and 120 ton, 660 and 1000 H.P.—Railway Age, 1940, October 12, p. 505—Railway Mechanical Engineer, 1940, October, p. 379.

Switching Locomotives—Chicago, Milwaukee, St. Paul & Pacific; 44-ton, 380 H.P.; two oil engines—Canadian Transportation, 1941, January, p. 5.

Switching Locomotives—Chicago, Rock Island & Pacific; 30-ton oil-mechanical engine—Railway Age, 1941, May 31, p. 985.

Switching Locomotives—General Electric Co.; 44-ton oil-electric—Railway Age, 1940, November 23, p. 784—Canadian Transportation, 1941, January, p. 5.

Switching Locomotives—Louisville & Nashville; oil-electric yard engines served by movable fuel and sand units—Railway Age, 1940, December 7.

Switching Locomotives—New York Central; oil-electric 70-ton, 400 H.P., at Auburn, N. Y.—Railway Age, 1941, March 22, p. 520.

Switching Locomotives—Oil-electric; design, operation and maintenance; paper by H. V. Gill—Railway Mechanical Engineer, 1940, November.

Switching Locomotives—Oil-electric; economy, availability and servicing—AREA, Proceedings, 1941, pp. 29, 128.

Switching Locomotives—Oil-electric; operating methods and costs—Railway Mechanical Engineer, 1941, July, p. 265—Mechanical Division, AAR, Proceedings, 1941—Railway Age, 1940, November 2, p. 620—Railway Fuel and Traveling Engineers Association, Proceedings, 1940.

Switching Locomotives—Oil-electric in yard work—Railway Mechanical Engineer, 1941, February, p. 67—Railway Gazette (London), 1940, December; 1941, May 2, p. 491.

Telephone Service—Illinois Central; private system for Chicago terminal district—Railway Signaling, 1941, September, p. 473.

Terminal Operation—Rough handling in yards and improper stowing of freight—American Association of Railroad Superintendents, Proceedings, 1941—Railway Age, 1941, July 12, p. 61.

Terminal Service—Discussion by industrial traffic managers—Railway Age, 1940, November 23, p. 797; 1941, May 24, pp. 878, 888.

Transfer Platforms—Chicago, Milwaukee, St. Paul & Pacific; 1800 ft. long; reinforced-concrete; with lift bridge crossing five tracks between two platforms—Wood Preserving News, 1941, July, p. 87.

Transfer Platforms—Roof construction—Railway Engineering and Maintenance, 1940, October, p. 681.

Yard Improvements—Canadian National; Atlantic division—Canadian Transportation, 1941, April, p. 165.

Yard Operation—English railways; switching during black-outs; use of oil engines—Railway Gazette (London), 1940, December; 1941, August, p. 181.

Yard Operation—Faster movements needed in switching and classification yards—Railway Age, 1941, May 24, p. 939.

Yard Operation—Modern improvements; gravity switching; signal equipment, etc.—Railway Signaling, 1941, July, p. 377.
Yard Operation—Rough handling of cars—Railway Age, 1941, July 12, p. 61—American Association of Railroad Superintendents, Proceedings, 1941.
Yards—Chicago, Milwaukee, St. Paul & Pacific; new L.C.L. facilities at Galewood (Chicago)—Railway Age, 1940, October 19, p. 542—Wood Preserving News, 1941, July, p. 87.
Yards—German railway yards and harbors on the Rhine—The Engineer (London), 1941, February 14, p. 111.
Yards—Great Northern; driveways in Minneapolis yards paved with concrete—Concrete for Railways, Bulletin of Portland Cement Association, Vol. 4, No. 4.
Yards—Louisville & Nashville; new De Coursey yards (Louisville) have car retarders, power operated switches, signals, floodlighting, snow melters and telephone from hump cabin to yard locomotive—Railway Age, 1941, January 4, p. 27; March 29, p. 533—Railway Signaling, 1941, January and February, pp. 22, 75.
Yards—Michigan Central; new signal and interlocking plant for yard at Windsor, Ontario—Railway Signaling, 1940, November—Railway Age, 1940, December 21, p. 949.
Yards—New York Central; reconstruction of 30th St. yards, New York—Engineering News-Record, 1940, September 19, p. 7—Railway Age, 1940, August 13 and 20.
Yards—Western Maryland; yard at Port Covington (Baltimore) revised for heavy war traffic—Railway Age, 1941, August 2, p. 200.
Yards—Floodlighting; 40-ft. cross arms on 75-ft. poles; St. Louis yard of Chicago, Rock Island to Pacific—Railway Age, 1941, July 5, p. 10.
Yards—Grade reductions justified by faster schedules—Railway Age, 1941, May 24.
Yards—Labor unions in England demand more pay and shorter hours for hump-yard switchmen; 83 yards, 1517 switchmen. Time refused; some pay granted—Railway Gazette (London), 1941, July 11, p. 45.
Yards—Location of marshalling (classification) yards and exchange sidings—Railway Gazette (London), 1941, January 17, p. 59.
Yards—Terminal facilities for moving trucks and trailers on and off railroad cars—AREA, Proceedings, 1941, p. 136.
Yards—Track; renewals of rails and ties—Railway Engineering and Maintenance, 1940, October, p. 636; 1941, June, p. 395.

Locomotive Terminals and Railroad Shops

Coal and Water Stations—Atlantic Coast Line; Orangeburg, S. C.; 250-ton concrete coal bin—Railway Age, 1941, May 3, p. 757.
Coal and Water Stations—Lehigh Valley; Towanda, Pa.; 300-ton bin—Railway Age, 1941, April 19, p. 681.
Coal and Water Stations—Louisville & Nashville; for servicing oil-electric switching engines—Railway Age, 1940, December 7, p. 862.
Coal and Water Stations—Pennsylvania R.R., Pittsburgh; 1250 tons storage—Railway Age, 1941, May 17, p. 840.
Coal and Water Stations—Relation to long engine runs, large tenders and fast trains—Railway Age, 1940, November 13, p. 750; 1941, January 4, p. 23—American Railway Bridge and Building Association, Proceedings, 1940, p. 157—Railway Engineering and Maintenance, 1940, November, pp. 744, 775.
Coal and Water Stations—Equipment for handling coal and cinders—Railway Age, 1941, March 8, pp. 424, 425.
Engine Houses—Canadian Northern, at Halifax; 18-stall round house and erecting shop—Canadian Transportation, 1941, April, p. 165; July, p. 363.
Engine Houses—Pennsylvania R.R., at Oil City, Pa.; windows of glass blocks reduce breakage—Railway Age, 1940, October 12, p. 512.
Engine Houses—Problems in modern service requirements—Railway Mechanical Engineer, 1940, November, p. 446.
Engine Houses—Treated timber in construction—Railway Engineering and Maintenance, 1941, August, p. 553.
Engine Houses—Heating and ventilating terminal buildings and shops—American Railway Bridge and Building Association, Proceedings, 1940, p. 147—Railway Engineering and Maintenance, 1940, November, p. 760.

Jacks—High-lift portable electric jacks for shops and locomotive terminals—Railway Mechanical Engineer, 1941, September, p. 382.
Sand House—Atlantic Coast Line, at Florence, S. C.; driers and storage bins—Railway Mechanical Engineer, 1940, December, p. 544.
Shops—Repair shop for oil-electric locomotives at Chicago terminal; Atchison, Topeka & Santa Fe—Railway Mechanical Engineer, 1941, January, p. 18.
Shops—Equipment for handling materials—Railway Age, 1941, April 12 and May 3, pp. 651, 762.
Terminals—Facilities for servicing oil-electric locomotives—AREA, Proceedings, 1941, p. 128—Railway Age, 1941, August 9, p. 227.
Turntables—Circle wall construction for pit—Railway Engineering and Maintenance, 1940, October, p. 677; 1941, February and September, pages 98 and 678.
Water Service—Atlantic Coast Line; water treatment plant at Savannah—AREA, Proceedings, 1941, p. 105.
Water Service—Illinois Central; emergency service for troop trains at Hattiesburg, Miss.—Railway Engineering and Maintenance, 1940, October, p. 641.
Water Service—Northern Pacific; water supply and treatment—Railway Engineering and Maintenance, 1941, May, p. 338.
Water Service—Union Pacific; treatment plant at Council Bluffs—Railway Age, 1940, September 7, p. 331.
Water Service—Developments in 25 years—Railway Engineering and Maintenance, 1941, June, p. 409.
Water Service—Modernizing facilities—American Railway Bridge and Building Association, Proceedings, 1940 and 1941—Railway Engineering and Maintenance, 1941, March—Railway Age, 1940, October 26, p. 583.
Water Service—Rules for maintenance of plant—AREA, Proceedings, 1941, p. 534.
Water Service—Steel tanks, corrosion—AREA, Proceedings, 1941, p. 97.
Water Service—Welding for pipes, etc.—American Railway Bridge and Building Association, Proceedings, 1941—Railway Engineering and Maintenance, 1941, November.

Rail-and-Water Terminals

Baltimore—Baltimore & Ohio; new Locust Point pier for export trade, 720 × 104 ft.—Railway Age, 1941, March 29, p. 566.
Baltimore—Port facilities and railway terminals—Civil Engineering, 1941, April, p. 223.
Baltimore—Western Maryland; new pier facilities at Port Covington for ore and other bulk shipments—Railway Age, 1941, August 2, p. 201.
Cape Town—New harbor works, with passenger station and freight yards on reclaimed land—The Engineer (London), 1941, January 17, p. 44; July 11, p. 23; September 5 and 12, pp. 149, 174.
Goodhope, La.—General American Tank Storage Terminals Co.; wharf rebuilt on piles of H-beams—Engineering News-Record, 1940, December 19, p. 815.
Great Lakes—Bulk traffic and St. Lawrence waterway project. By L. K. Sillcox—Mechanical Engineering, 1941, April, pp. 261, 265.
Great Lakes—Grain traffic, 1939–40—Canadian Transportation, 1940, November, p. 596.
Great Lakes—Paper on "Great Lakes Ports and Waterways," by Lt. Col. Duhamel—Military Engineer, 1941, p. 123.
Mobile—Alabama State Docks extension; wharf, tracks, roads—Engineering News-Record, 1941, February 27, p. 337.
Montreal—Canada Steamship Line; package freight terminal with three ship berths and tailboard space for 100 trucks—Canadian Transportation, 1940, December, p. 647; 1941, February, p. 97.
Montreal—Port and harbor traffic—Canadian Transportation, 1940, November and December, pp. 591, 619.
Newport News—Chesapeake & Ohio; 25-ton dock cranes for loading scrap on steamers—Railway Age, 1941, May 10, p. 807.
New York—Rail-and-water terminals; control of railway export traffic—AREA, Proceedings, 1941, p. 46.
Richmond—Municipal deep-water terminal—Engineering News-Record, 1940, November 7, p. 593.
San Diego—Harbor and terminal facilities—Civil Engineering, 1941, July, p. 421.
Vancouver—Port and harbor works—Canadian Transportation, 1941, January, p. 49.

Car Ferry—Canadian Northern; large ice-breaker car ferry steamer "Charlottetown" went ashore at Prince Edward Island—Canadian Transportation, 1941, July, p. 413.

Car Ferry—Danish State Railways; new steamer for Great Belt crossing; 203 ft. long, 17 to 19 ft. draft; triple screw (one at bow)—Railway Gazette (London), 1941, September 12, p. 254—Also the new "Staarebelt", 339 ft. long, 13 ft. 3 in. draft; twin-screw with oil engines of 5000 H.P.—Railway Gazette (London), 1941, August 15 and September 12, pp. 158 and 254.

Car Ferry—New York; harbor service rates held reasonable by I.C.C.; control of car-float freight movements—Railway Age, 1941, January 18, June 28, pp. 191, 1191—AREA, Proceedings, 1941, p. 47.

Car Ferry—New York; new car-floats, and tugs for Pennsylvania R.R.—Railway Age, 1941, July 19, p. 129.

Car Ferry—Pere Marquette R.R.; Lake Michigan car ferry service and new steamer "City of Midland"; 406 ft. long, 17½ ft. draft; 34 freight cars—Railway Age, 1940, October 5, p. 479; 1941, March 8, p. 433—Marine Engineering, 1941, April, p. 88—Canadian Transportation, 1940, October, p. 541.

Car Ferry—Seatrain Line; "Texas" and "New Jersey" for New York, Havana and New Orleans service; 465 ft. long; 100 cars on multiple decks—Marine Engineering, 1940, November, p. 110.

Car Ferry—Seatrain Line; interchange with railroads—Railway Age, 1941, January 25, p. 231.

Car Ferry—Swedish State Railways; new boat for Malmo–Copenhagen route; 310 ft. long; oil engines of 4500 H.P.—The Engineer (London), 1941, September 12, p. 176.

Car Ferry—Tigris River, at Bagdad; to be replaced by bridge—Railway Gazette (London), 1941, July 4, p. 4.

Car Ferries—Possible use after the war as substitutes for bridges destroyed—Railway Gazette (London), 1940, November 1, p. 450.

Ports—Control of car service at ports to facilitate loading ships with war material—AREA, Proceedings, 1941, pp. 46, 776—Railway Gazette (London), 1941, June 13, p. 641—Railway Age, 1941, February 15, p. 328; May 24, p. 923.

Report of Committee 9—Highways

J. G. Brennan, *Chairman,*
W. J. Backes
F. D. Batchellor
H. D. Blake
H. E. Brink
A. P. Button
A. R. Dewees
G. N. Edmondson
C. F. Edwards
P. W. Elmore
H. L. Engelhardt
P. M. Gault*
A. S. Haigh
J. P. Hallihan
H. A. Hampton
W. J. Hedley
Warren Henry
C. D. Horton
Maro Johnson
R. B. Kittredge
A. E. Korsell
Fred Lavis
E. E. Mayo
G. P. Palmer
W. C. Pinschmidt
T. M. Pittman
Bernard Blum, *Vice-Chairman*
L. J. Riegler
Frank Ringer
L. S. Rose
H. M. Shepard
C. K. Smith
W. C. Swartout
C. A. Taylor
V. R. Walling
R. E. Warden
J. L. Way
W. L. Young
Committee

* Died September 16, 1941.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, including recommended revisions ..... page 168

2. Design and specifications for highway crossings at grade over railway tracks, both steam and electric, collaborating with Committee 1—Roadway and Ballast, and with American Society of Municipal Engineers, and American Transit Association.

   No report.

3. Comparative merits of various types of grade crossing protection, collaborating with Committee 10—Signals and Interlocking, Signal Section, AAR, and Highway Research Board.

   Progress report—presented as information ..... page 169

4. Requisites for location, number and arrangement of automatic signals, automatic gates and auxiliary signs for rail-highway grade crossing protection.

   Final report, submitted for adoption and publication in the Manual ..... page 172

5. Method of classifying grade crossings with respect to hazard.

   No report.

6. Report requisites for flexible barrier type of grade crossing protection, collaborating with Signal Section, AAR.

   No report.

The Committee on Highways,
J. G. Brennan, *Chairman.*

Bulletin 428, December, 1941.

Paul M. Gault

The following resolutions in reference to Paul M. Gault, prepared and read by the chairman, were unanimously adopted at a meeting of the committee:

Whereas, Almighty God, in the exercise of His Divine will, has taken from us our honored friend and esteemed member, Paul M. Gault; and

Whereas, We desire to express our recognition of the work done on behalf of this committee by Mr. Gault, therefore we, Committee 9—Highways, of the American Railway Engineering Association, now pause and pay our last tribute to the honored memory of our sincere friend, to express our appreciation of his work in our behalf, and our sincere sorrow that his death has deprived this committee of a valued member; therefore be it

Resolved, That in the death of Paul M. Gault this committee laments the loss of our member, friend and business associate.

Resolved, That these resolutions be spread upon the minutes of this meeting.

Report on Assignment 1

Revision of Manual

A. S. Haigh (chairman, subcommittee), Bernard Blum, H. E. Brink, A. P. Button, P. W. Elmore, Maro Johnson, R. B. Kittredge, E. E. Mayo, G. P. Palmer, T. M. Pittman, Frank Ringer, H. M. Shepard, C. K. Smith, C. A. Taylor, V. R. Walling, J. L. Way, W. L. Young.

Your committee recommends that the following changes be made in the Manual:

Highway crossing sign reflectorized type—page 9–20, Fig. 902; page 9–20.1, Fig. 903; page 9–20.2, Fig. 903-A; page 9–27, Fig. 909; page 9–28, Fig. 910; drawings on pages 9–34.6, 9–34.7. That the present standard for background of reflector button crossbuck signs be changed from black to white and the letters on these signs be changed from white to black. The Joint Committee on Grade Crossing Protection, AAR, has made this change in its Recommended Standards. The recommended change will give better daylight indication.

Page 9–20.2. That a fourth note be added as follows:

"4. It is permissible to place reflectorized signs on existing post." That the number of the drawing be changed to agree with the latest revision of the AAR Signal Section Drawing 1691.

That "Stop on Red Signal" and "Stop When Swinging" signs shall continue to have a black background and white letters where reflector buttons are used, but where the background is to be of reflecting material, it shall be white or silver with black letters. Pages 9–22 and 9–24, Figs. 904 and 906.

That the informative sign indicating number of tracks be treated the same as the "Stop on Red Signal" and "Stop When Swinging" signs. Pages 9–19, 9–22, 9–23, 9–24, 9–25 and 9–29, Figs. 901, 904, 905, 906, 907, and 911.

Page 9–22, Fig. 904; page 9–23, Fig. 905; page 9–24, Fig. 906; page 9–25, Fig. 907. These drawings cover highway crossing signals both wigwag and flashing light type similar to Signal Section Drawings 1651-C, 1652-C, 1653-C, and 1654-C. The latter drawings give reference numbers for parts used in the assembly and it is recommended that the above figures be revised to show this information.

After Fig. 907 on page 9–25, Signal Section Drawing 1686-B Highway Crossing Flashing Light Signal Assembly, Cantilever type, should be inserted.

Beginning on page 9–26 and extending to and including page 9–33 a number of Signal Section drawings are reproduced as Figs. 908 to 915, inclusive. These drawings, covering reflector type highway crossing signs, have been revised by the Signal Section to provide for both the synthetic enamel and vitreous enamel finish, together with minor revisions. It is recommended that the latest issue of these drawings be printed in Chapter 9.

Beginning on page 9–34.2 and extending to page 9–34.7 are a number of drawings covering highway crossing signs for suspension over highway. These drawings have not been issued by the Signal Section and do not carry Signal Section numbers. It is recommended that a figure number be added under each of these drawings. It may be desirable also to request the Signal Section to assign numbers to these drawings and include them in the Signal Section manual.

Report on Assignment 3

Comparative Merits of Various Types of Grade Crossing Protection

Collaborating with Committee 10—Signals and Interlocking, Signal Section, AAR, and Highway Research Board

H. M. Shepard (chairman, subcommittee), F. D. Batchellor, H. D. Blake, H. E. Brink, A. P. Button, A. R. Dewees, C. F. Edwards, J. P. Hallihan, H. A. Hampton, Warren Henry, R. B. Kittredge, Fred Lavis, W. C. Pinschmidt, C. K. Smith, R. E. Warden.

Your committee submits the following as information:

It has confined its work this year to tests of two types of sheet reflectorized crossbuck signs now on the market, which have been developed for use at grade crossings. The cost of these signs is substantially less than the cost of reflector button signs.

Scotchlite Reflectors, manufactured by the Minnesota Mining & Manufacturing Company, St. Paul, Minn.—This is a luminous material using a powdered glass for reflecting light and is said to be waterproof, with visibility to 1,000 ft. and legibility at 400 ft. The material is cemented to a wooden crossbuck sign and the letters are painted on the material. This material can also be used on a metal base.

The first test installation was made at 113th Street near Rockwell Street in Chicago on the Baltimore & Ohio Chicago Terminal Railroad, on August 21, 1940. This consists of two signs, one on metal and one on wood. These signs are beginning to show weathering, but their reflecting qualities are still good. Furthermore, these are the old type sign which has since been improved by the use of a silver colored reflecting material.

Two of the new type signs consisting of two crossbucks were installed on the Baltimore & Ohio Chicago Terminal Railroad, one at 109th Street near Rockwell in Chicago, and the other at Central Avenue near 103rd Street outside of Chicago in the open country. The signs at Central Avenue were installed December 10, 1940 and at 109th Street on April 14, 1941. Both of these installations are in excellent condition and working very satisfactorily.

Decalcomania Transfer Process, manufactured by the Cuneo Press, Chicago.—This is a waterproof reflecting material on paper backing which can be applied to a wood or metal sign by simply wetting the material, removing the paper and immediately applying to the sign with a roller. The letters are printed on the material before it is applied so that no sign painting is necessary.

On March 3, 1941, an installation was made of two reflectorized crossbuck signs at the 105th Street crossing just west of Western Avenue in Chicago on the Baltimore & Ohio Chicago Terminal Railroad. These signs were constructed in accordance with AREA standard 6-ft. arm, 50-deg. angle. Visibility and legibility are satisfactory.

Figs. 1 and 2 show daylight and Fig. 3 and 4 show night indications of self reflecting material.

The committee is of the opinion that this type of material provides a satisfactory night indication.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Report on Assignment 4

Requisites for Location, Number and Arrangement of Automatic Signals, Automatic Gates and Auxiliary Signs for Rail-Highway Grade Crossing Protection

A. P. Button (chairman, subcommittee), H. D. Blake, H. L. Engelhardt, A. S. Haigh, H. A. Hampton, W. J. Hedley, Warren Henry, C. D. Horton, Maro Johnson, A. E. Korsell, W. C. Pinschmidt, L. J. Riegler, C. K. Smith, W. C. Swartout, C. A. Taylor.

Your committee recommends the following requisites as recommended practice for publication in Manual:

REQUISITES

1. The word "signals" as hereinafter used includes automatic signals, automatic gates and auxiliary signs attached thereto.

2. Signals shall give warning to vehicles for trains moving over all regularly operated tracks.

3. A sufficient number of signals shall be provided to warn highway traffic approaching the crossing from any direction.

4. On streets improved with paved roadways and curbing, signals shall generally be so located at the side of the roadway that all portions of the unit clear the face of the curbing by at least 12 inches. On roadways having no curbs, signals shall be located at the side of the roadway with a minimum of 6 feet from the center of the signals to the edge of the roadway. Highway crossings having multiple lanes with a physical division

between opposing traffic lanes, may require a left side installation protecting approaching traffic in addition to the right side installation.

(a) *Right Angle Crossings And Left Hand Forward Skew Crossings.*—Signals should be located as close as practicable to the exterior railroad tracks to be protected but should have not less than 10 feet side clearance from center line of track.

(b) *Right Hand Forward Skew Crossings.*—Signals should be located in such a position as to permit vehicles, stopping opposite the signals in any approaching traffic lane, safe clearance from the track.

5. Where groups of tracks of the same or different railroads are separated by space sufficient to permit three or more vehicles to occupy one traffic lane with safety, each group should be given protection separately, if required, with interconnecting signals if necessary.

Memorandum

Requisites for automatic crossing gates, together with typical location plans therefor, are now incorporated in the Manual, pages 9–43, 9–44, 9–45 and 9–46; and a typical installation for the location of flashing lights or wigwag signals is also incorporated in the Manual, page 9–34.

Adoption of the requisites set forth above would involve the following changes in the Manual:

Page 9–34, Fig. 916

The distance of 15 ft. for the location of the flashlight or wigwag from the center line of the exterior track would be 10 ft. minimum side clearance.

Page 9–44, Case 1

The typical location plan for automatic crossing gates would have to be revised for the distance from the exterior track to show 10 ft. minimum side clearance, and the 6-ft. distance from the edge of the pavement would have to be modified to show 12 in. minimum clearance from the face of the curb where curbs obtain.

Page 9–45, Case 2

This would require modification to show 12 ft. minimum clearance between the face of the curb to the gate arm in the raised position where curbs obtain.

Page 9–46, Case 3

This would have to be modified to show the minimum side clearance of 10 ft. from the center line of the exterior track and to show 12 in. minimum clearance from the face of the curb to the gate arm where curbs obtain.

Report of Committee 24—Cooperative Relations with Universities

E. T. Howson, *Chairman,*
Lem Adams
J. B. Babcock, III
W. C. Barrett
T. A. Blair
F. T. Darrow
R. E. Dougherty
O. W. Eshbach
W. D. Faucette
R. H. Ford*
P. M. Gault**
E. M. Hastings
Clark Hungerford
R. B. Kittredge
B. R. Kulp
F. R. Layng
F. A. Russell
W. C. Sadler
F. S. Schwinn
Barton Wheelwright
C. C. Williams
Committee

* Deceased, May 27, 1941; ** Deceased, September 16. 1941.

To the American Railway Engineering Association:

Your committee submits as an introduction to its second report a brief statement of its objectives ..... page 176

It also reports on the following subjects:

1. Stimulate greater appreciation among railway and university officers of
   (a) the fundamental importance of instruction in transportation and economics, and
   (b) the necessity for presenting courses of instruction based on current railway conditions and taught by men of adequate ability and experience.

   No report.

2. Call to the attention of universities and colleges such information and conclusions developed by the Association as thought to be of special interest or value to them.

   The committee has sent copies of its last report to the presidents and deans of engineering colleges of the country to acquaint them with the work that the Association has initiated through this committee in their field. It also has other activities in progress on which it is not yet prepared to report.

3. Develop means of bringing to the attention of railway managements the value of a technical education as a qualifying factor for young men desiring to enter railway service with a view to advancement.

   Progress report, presented as information ..... page 177

4. Stimulate a greater interest in the science of transportation among university and college students and create thereby a greater appreciation of the place of transportation in our national economic structure, cooperating with organizations of university and college students and contributing to their activities in such manner as may be mutually arranged.

   Progress report, presented as information ..... page 185

5. Develop means whereby facilities of the universities may be made directly available for research work of the Association and the railway industry by cooperative effort between the staffs of the universities and the committees of the Association.

   No report.

The Committee on Cooperative Relations with Universities,

E. T. Howson, *Chairman.*

Foreword

In the continuation of its work during the last year, your committee has gained a new appreciation of the importance of its task. It recognizes that the railways will face an era of greatly intensified competition when the present emergency has passed. It recognizes also that no industry is more efficient than its leadership. Its studies disclose that the railways are no longer attracting the most promising of the young men as they have done heretofore, but that, on the contrary, they are today failing to meet the more aggressive competition of other industries for the more capable young men who are graduating from our colleges and universities. We find furthermore that many of these colleges and universities are not only abandoning instruction in transportation subjects, but are discouraging young men from preparing for service with the railways. Your committee believes this trend to be of serious concern to railway managements and is, therefore, endeavoring to acquaint them with the facts.

The situation is not, however, without promising developments. Among these is the awakening of several of our most alert railways to the importance of initiating measures necessary to provide adequate personnel in the future, and some of them have progressed sufficiently far to secure initial results therefrom. Also among the colleges, the response of a number to overtures of the committee has been most encouraging, especially significant being the renewal of interest in this subject in the Society for the Promotion of Engineering Education.

Your committee submits its report for the year with a realization of the fact that its task is educational in character and is, therefore, long continuing.

Robert H. Ford—Paul M. Gault

Your committee suffered the loss by death during the year of two of its most active and valued members: Robert H. Ford and Paul M. Gault, and records here its keen sense of loss in their passing and its equally keen appreciation of the contributions which they made to our work.

To Mr. Ford, more than to any other member of this Association, is due the credit for the creation of this committee. Long an ardent believer in the importance to the railroads of a constant influx of young men of ability and education, he viewed with concern the rising tide of restrictions that made it more difficult for the railways to attract such men in competition with other industries. With the energy that characterized his every action, he no sooner sensed the danger that was arising to threaten the railway leadership of the future than he set about to devise ways to develop a correction. He visualized the problem as that of arousing railway officers of the present generation to the need for bringing into their organizations young men with promise of executive ability and properly educated. Seeing the American Railway Engineering Association as the organization best prepared to develop the facts regarding this problem and to lay these facts before railway managements, he recommended to the Board of Direction of the AREA that it create a committee to make an intimate study of the problem. The Board of Direction acted favorably on this recommendation and created this committee in 1924, making Mr. Ford chairman and leaving the formulation of the scope of the work and the selection of the remaining personnel largely in his hands.

This committee, under Mr. Ford's leadership, undertook its work aggressively and presented reports to the Association in 1924–1930. Mr. Ford continued as chairman of the committee until the depression made it necessary for the Association to suspend the activity of this committee in 1932.

When the committee was reorganized in 1939, Mr. Ford was reappointed a member and again took a keen interest in its objectives. His vision of the possibilities of this committee's service was a constant inspiration to the members who remain.

Mr. Gault came on to the committee when it was recreated in 1939. His acceptance of appointment reflected his keen interest in its objectives. Long a believer in the opportunities offered by the railways for a career for active, ambitious young men, he entered with enthusiasm into our work and accepted appointment as chairman of a subcommittee, preparing a preliminary report which was incorporated in the report of this committee and presented to the Association last year. Before the convention, however, failing health compelled him to take a leave of absence and he was unable to present his report in person. Continued ill health made it advisable that he relinquish this subcommittee chairmanship this year, although he maintained keen interest in our work until he passed away suddenly on September 16, 1941.

Report on Assignment 3

Develop Means of Bringing to the Attention of Railway Managements the Value of a Technical Education

As a Qualifying Factor for Young Men Desiring to Enter Railway Service with a View to Advancement

F. S. Schwinn (chairman, subcommittee), W. C. Barrett, T. A. Blair, R. E. Dougherty, O. W. Eshbach, E. M. Hastings, R. B. Kittredge, B. R. Kulp, F. R. Layng, Barton Wheelwright, C. C. Williams.

Your committee submits the following report as information.

The first progress report on this subject appeared on page 157 of Vol. 42, of the Proceedings for 1941. It was designed to indicate why railway managements should be interested in giving employment to desirable college men and to give candidates for such employment a clear idea of what management expects of them. Your committee's concluding observations in that report were extensively supported by comments and opinions of railway executives and engineers.

In the present report, your committee develops the answers to four points: (a) Is there a recognized present demand for technical and other college graduates on the railways? (b) Why should there be such a demand? (c) Is the demand evidenced by aggressive action on the part of the railways? and (d) What is the college educator's view of the railway attitude? It hopes that these answers may prove helpful to the railways.

(a) Is There a Recognized Present Demand for Technical and Other College Graduates on the Railways?

Your committee again addressed several of the railway executives who had furnished some of the valuable comments included in its first report to ask their views regarding the potential demand among the railways for men of the type which your committee had described as desirable college men. Because of the value of their considered opinions on the subject, partial quotations from their letters follow.

From Ralph Budd, president of the Burlington Lines:

> It has been necessary, during the past ten years, to curtail greatly the number of new employees entering railroad service. This applies to all depart-

ments and branches of the service, but the reduction was probably greater as it applied to the employment of technical and other college-trained men than it was in some other branches of the service. The effect of this has not been very noticeable during the past few years, possibly due to the reduction in the number of officers, but I am of the opinion that it will be felt and will be serious during the next ten years. This is true not only on account of the small number of college-trained men taken into the service, but also on account of the very few young men entering railroad service in any capacity, with or without college training. For these reasons, I believe that the potential demand for young men who have the necessary ability, personality and training to make possible their development as competent railroad officers will be greater during the next ten years than it has been during the past decade.

On most railroads many of the officers have reached middle age and some are considerably older. It is not likely that the number of officers can or will be reduced much below the present level. If the official staffs are to be maintained, even at the present strength, the increasing age of the officers will make replacements necessary and opportunities for advancement will be better than they have been for some time.

It is true that in the last few months many recent college graduates have entered railway service, but many of them lack the specific, technical education to fit them for promotion to positions where a technical education is almost a requisite. It would appear that most of the technical graduates of the last year or two have been absorbed into other industries or into military service, and comparatively few of them are now available to the railroads.

I think that an effort should be made to recruit into railroad service young men who have a technical education, and the other attributes that make them potential supervisors, and that they should be given as extensive training in the various branches of service as possible. In doing so, consideration should be given to all of the factors, including the time element, so that when it becomes necessary to appoint junior officials, either as replacements or as additional staff, such men will be available, along with others who, although they do not have a technical education, do possess other attributes that go to make successful officers.

From J. R. Downes, vice-president of the Pennsylvania Railroad:

Our policy has been maintained throughout many years, i.e., the employment of young men of technical education for training as supervisors has continued in volume sufficient to maintain our personnel. While there has been an occasional "lean" year when we were not warranted in taking for training young men of technical education beyond our opportunity for placing them in supervisory positions on the completion of their special apprenticeship, the comparison of the ten-year period since 1930 with a like period prior to 1930 does not present the condition you are discussing.

At present, of course—with us, as in all other industry—the employment of young graduate engineers is influenced by the Selective Service Act. So far this year, however, 9 graduate engineers have been added to the group in training for supervisory positions in the maintenance of equipment department and 35 in the maintenance of way department, these figures being net after deducting those called for military service from the young men accepted for employment.

From H. M. Lull, executive vice-president of the Southern Pacific Lines:

This problem is mainly one of interesting college-trained men in taking employment in those departments of railway service that do not actually call for a technical education as a basis for the kind of work to be performed. For vacancies in railway engineering and mechanical organizations, consideration ordinarily is not given applications from men who have not had a technical education fitting them for such work. What is really needed is a more general infiltration of college-trained men in train service, station work, traffic work, accounting departments, general transportation activities, etc. It is to be expected that non-technical college men will form a majority of the college men applying for employment in these non-technical services.

Obviously, any railroad organization would be strengthened by the employment of a substantial number of such college-trained men in these non-technical services. Except to the extent to which labor organization seniority rules may limit advancement until sufficient age and experience has been gained to enable such men to qualify for minor supervisory positions, they ought, on the average, to do as well in railway work as in most other lines of endeavor. After a minor supervisory position has been reached, opportunities for further advancement should be at least equal, if not superior, to those in other lines of work.

A surprisingly large number of the sons of men in all fields of railroad service are now obtaining the advantage of a college education. Unfortunately, there seems to be a general tendency for these young men to seek employment outside of the railroad industry. It is the exception rather than the rule for railroad men, whether in high or low positions of railroad employment, to urge their college-trained sons to take up railroad work.

The reservoir of college-trained men for railroad service naturally ought to be made up largely of the sons of men who have spent their lives in railroad service. Much could be done to attract college men into railroad service from families supported by railroad employment, by carrying on a carefully-planned program of encouraging interest in and appreciation of the opportunities of railroad service among officers and employees having sons who are obtaining college educations. Timely and appropriate articles in railroad employees' magazines would be helpful in engendering interest.

From F. E. Williamson, president of the New York Central System:

It is our belief that, where possible, the employment of young technical men should be encouraged. We endeavor to develop contact with various universities with the objective of employing undergraduates during the summer months, with the thought that some of these men may prove to be candidates for permanent employment after graduation. This gives the men a chance to get some idea of railroad work and conditions and it gives us the opportunity for observation of their qualifications prior to permanent employment. For the present at least we are experimenting, but hope within a year or two to crystallize some more definite method of procedure that we hope will prove mutually advantageous to young men desiring railroad employment and to the railroad company. Your committee is engaged in the consideration of a subject that is well worth while.

It appears from these quotations that there is a real and well-recognized present demand on the part of the railways for desirable college men. However, information obtained from the colleges does not support the assumption that this demand is being generally filled by active recruiting of the better available graduates. This phase of the subject will be covered later in this report.

(b) Why Should There Be a Large Present Demand for Technical and Other College Graduates on the Railways?

In its first report, your committee observed in part that "Railway managements should be interested in giving employment, training, encouragement and opportunity to desirable college men in order to provide a reserve from which to draw future supervising officers, managers and executives . . . ." The question arises: is the need for such a reserve greater now than it was ten or twelve years ago? If the need is greater, it follows that there should be an even greater demand than then.

To develop this phase of the subject, a few representative eastern and western railways furnished information regarding the average ages of their officer personnel in the operating department, including transportation, mechanical, engineering and maintenance officers of the grades of superintendent and above. These data showed that, considering the officers in charge of over 36,000 miles of lines, the average age increased from 51.3 years in 1929 to 55.1 years in 1941. The average officer on these railways is now nearly 4 years older than the average officer of 12 years ago, and retirements on account of age will be increased correspondingly. This very clearly illustrates the need of a greater reservoir to meet the future requirements. While the railways unquestionably have trained and qualified men at present to replace these officers upon their retirement, that fact does not assure them of an equally satisfactory situation ten or twenty years hence.

There is another factor which enters into the possibilities attached to this phase of the subject. Information at hand indicates that there are probably one-fourth fewer officers at present than there were in 1929. Without discussing the several causes for this reduction, there is the possibility that conditions may require increasing the future official personnel. Should this occur, promotion would be accelerated and the difficulty to be expected in finding qualified men would be greatly increased.

Upon considering the several facts mentioned, it is quite apparent that there should be a definite demand on the railways for desirable college men fitted for training as supervisory officers.

(c) Is the Demand for Technical and Other College Graduates Evidenced by Aggressive Action on the Part of the Railways?

For the purpose of developing the extent to which railways have been contacting educational institutions for the purpose of selecting desirable technical graduates for employment, 30 representative colleges were requested to furnish this information as well as data covering the activities of other industries. Among the other industrial groups which are most prominent in their efforts to secure desirable technical men are airline, airplane, arms and munitions, automotive, chemical, construction, electrical equipment, machinery and machine tool, mining and smelting, oil, power, radio, scientific instruments, steel, telephone and textile.

Replies were received from 27 colleges and engineering schools located in every section of the country. The following tabulation gives a composite presentation of the data furnished.

Data Reported by 27 Technical Colleges	From Class of 1940 Number	1940 Percent of Total	1941 Number	1941 Percent of Total
Contacts made with colleges for the purpose of employing technical graduates by representatives of:				
Railways	37	1.6	49	1.7
Other industries	2,219	98.4	2,741	98.3
Technical graduates employed as the result of such contacts by:**				
Railways	76	2.1	*	
Other industries	3,604	97.9	*	

* The major portion of the information was furnished prior to the close of the year 1940–1941 and therefore does not include the number of graduates employed by contacting companies.

** Partial information received on the subject indicated that approximately 75 percent of the total number of technical graduates were placed as the result of the contacts reported. The balance were placed by other means.

These returns do not mean that 37 different railways contacted the colleges in 1940, as the railways referred to almost invariably contacted several colleges. The tabulation does show that:

1. Only one out of every 58 contacts looking to the employment of technical graduates was from a railway.

2. Only one out of every 50 graduates placed through such contacts was employed by a railway.

3. There was an increase in the number of contacts made by railways in 1941, compared with 1940 and this was proportionately greater than shown by other industries.

The reports from the colleges also indicated that nine, or one-third of those reporting, received no inquiries from railways in 1940. This condition was improved to some extent when only six colleges made that report for 1941.

It does not appear that the railways can be considered to be as aggressive in their solicitation of new personnel having the desirable advantage of a college education, and it may be concluded that the demand for desirable graduates has not yet been thoroughly developed. Some slight improvement has been made in the interest shown by the railways, as evidenced by the larger number of contacts made by them and the larger number of colleges contacted.

The evidence points to the fact that the railways, with but few exceptions, are making little or no effort to employ and train desirable and qualified college men. Your committee feels that this apparent lack of interest in the face of a recognized demand is regrettable, and therefore directs attention to the comments received from railroad executives and reported by this committee with its own concluding observations in Vol. 42 of the Proceedings, as well as to the comments quoted earlier in this report.

(d) What is the College Educator's View of the Railway Attitude?

The general railway attitude toward, or possible lack of interest in college graduates during the last decade has naturally affected that of the college deans, professors and personnel directors who, in turn, either directly or indirectly, reflect their views upon the students. It is certain that the railway managements cannot desire that the students of today should gain the wrong impression of the railways. Furthermore, these students will not prepare themselves for railway work if they are not made to understand that they are wanted and that a worthwhile future awaits them on the railways. It is at this stage, the development stage of the student, that the college educator's views are of real importance to the railways.

In furnishing the data which your committee requested, a number of unsolicited comments were included. They generally voiced a welcoming, friendly spirit toward the railways and offered their help. But some of them were quite critical. It is felt that both the cooperative spirit indicated and the criticisms should be brought to the attention of railway managements. Representative quotations follow without identification of the writers. Among the welcoming cooperative comments, we read:

> I shall be glad to cooperate with you in any way possible that will be helpful in formulating a comprehensive and satisfactory long range program for the recruiting and training of engineers for the railroad industry. The manufacturing industries have had a comprehensive recruiting and training program for many years. The transportation industries, highways and railroads, have been and still are slow to adopt such a program. This year, for the first time, we had recruiting visits by the representatives of two important railroads. I hope that other railroads will adopt that policy because visits of that type do a great deal to call the possibilities of employment in the railroad field to the attention of senior engineers.

Another wrote:

> I am pleased to note that you are collecting these data as I have felt for some time that the railroads should take an active part in obtaining good men from our graduating classes. Personnel men start coming here in November and December to interview men who are graduating the following June. This means that most of the good men are pretty well lined up by early spring. I am, personally, very much interested in railroad work and would like to see more of our men placed with railroads. If the railroads are to obtain young men of high standing, they should get busy at an early date.

From another, we read:

> If I can be of assistance, kindly let me know. For 20 years I have tried to place all of our graduates whom I could recommend. I feel that the railroads have not taken full advantage of their opportunities to recruit able technical graduates.

From still another:

> I sincerely hope that you are successful in establishing a close relationship between the railroads and the engineering schools throughout the country.

While from another we heard:

> This university will always be pleased to cooperate fully with the railroads, as well as with government and industry in the placement of its graduates. In recent years we have received practically no inquiries from the railroads. Even in peace times in the last 20 years certain industries have regularly sent their personnel officers to consult with my office to learn the names of outstanding top men. In 1941 they appear to be willing to take almost any one who is a graduate, so great is the competition.

Some comments combined the cooperative spirit with mild criticism. One read:

> The industries that regularly recruit engineering graduates, provide them with planned training courses and guide them in their professional advancement, have built up intelligent, alert, industrious and loyal personnel. As a

teacher, I have observed that students know about these companies; and the better ones are anxious to secure employment with them. From my early association with railroading, I know how thorough the railroads are in the selection of high quality materials, in the performance of good work, and in the development of efficient service. Therefore, I have often wondered when they would initiate the same policies in the selection of new engineering employees. I wish you every success in your timely and important venture.

From another:

We are very happy to learn that the American Railway Engineering Association has established a committee for cooperation between the various railroads and universities. We have been very much concerned over the policies of the railroad companies with regard to the placing of university students in railroad work. On several occasions we have pointed out to a number of railroad officials that they are missing an opportunity in the placement field. In fact it has been our feeling that most of the railroad companies have been "asleep at the switch." When one realizes the fact that most of the larger industries have set up comprehensive programs and have developed excellent recruiting policies, is it little wonder that a number of boys are reluctant to enter the railroad field as a career? Last summer we had an experience with one of the railroad companies which we thought would develop nicely. One of our students was placed on an extra gang doing manual work. Neither the student nor we objected to this type of work because we felt that it could give the boy an opportunity to become acquainted with track laying and familiarize him with maintenance problems. It seemed rather strange to us that at the conclusion of a successful period in this type of work the company could not find a permanent position for this young man.

Again we are told:

As a rule, the men who actually go into railroad work do not anticipate the field they are to work in and do not prepare for it by specialized training. They are run-of-the-mine graduates who drift into the field. They make good in railroad work because they have had a good training in the fundamental mathematics, physical sciences and engineering principles. It is for the railways to decide first of all whether they would be benefited materially by having more technically-trained men of high quality in their organizations. If that point is decided in the affirmative, the roads will have to set about deliberately and intelligently to make their service attractive to that class of men. The ways and means will vary on different roads, but the objective will be the same in all cases: To develop a spirit of loyalty to the road and satisfaction in the service. The colleges of engineering will, naturally, welcome an additional outlet for their graduates. If the time comes when a college student can look forward with confidence to a railroad career, he will demand special training for that career from the colleges.

Still another wrote:

It is encouraging to know that someone is attempting to do something about getting college men into the railroads, for each year we have some good seniors who are interested in that field, but we have had great difficulty in finding opportunities for them. I do not think that I have had an inquiry directly from a railway since I have been at ..... and my impression

is that the situation was not much better at ..... Like a great many other professors of engineering, I would be glad to help out on the idea of cooperation between the railways and the universities. I have felt that railway work was one of the best trainings that a man could get for almost any line of subsequent work.

But it appears that the railway attitude has caused some educators to become definitely critical—almost to the point of being pessimistic. One such comment read:

> When I returned to ..... I thought the absence of any number of engineering graduates placed with the western railroads in the last two decades, and the peculiarly favorable position of this university, presented an opportunity for us to cooperate with the railroads in offering training in engineering and business which might appeal to the railroads' managements. I sold the general idea to the president of the university and next went to the president of one of the transcontinental railroads who was then a member of our board of trustees. He courteously heard my story and collapsed my balloon with this statement, "I should advise any young man entering the railroad industry to enter directly from high school and establish his seniority as early as possible." Now, although a third decade has passed since my own brief railroad experience, your letter has again raised a ray of hope that it may still be possible to improve the cooperation between the railroads and the universities in the training of engineers and others.

Then another wrote:

> No railroad representatives have called on us. During the last few years we have placed a few men in railroad work, but our experiences have not been very happy. It seems to be the policy of all railroads, when it becomes necessary to lay off men, that those most recently employed are the first to go, without regard to the qualifications of the individuals. I feel that this is such an extremely poor policy that I would not recommend good men going with the railroads as long as it obtains. Until the railroads adopt a better policy for taking care of young technically-trained graduates, we shall continue to discourage our boys from entering railroad service.

Still other comments were:

> One railroad approached us with the object of securing the services of a technical graduate of the class of 1940. That railroad offered 62 cents per hour and an apprentice course in a highly organized shop where it would be much more difficult to advance than in other competing industries.

And:

> Six electrical engineering students were placed with a railroad making inquiry by mail, but the work was only of a temporary nature.

Also:

> So far as we know, only one of our graduates of this year entered railroad service. One of our alumni came here and got him. Other industries were more active than usual this year in sending representatives here to employ June graduates.

The foregoing are representative of the comments received. They do not present a very desirable picture of the general attitude towards the railways. Fortunately, if this is

a true picture of the general attitude, there are a number of railroads which are proving the exception to the rule. Your committee will undertake to describe in a later report the methods used by these railroads in recruiting and training desirable college graduates. Your committee has also collected extensive information from a number of representative companies selected from the principal industrial groups. It proposes to develop clearly the present competition within industry for the services of desirable technical and other college graduates in its report for the coming year.

Summary

In the light of the information and data here presented, your committee feels justified in presenting certain general observations. These follow:

1. There is a real demand on the part of the railways for desirable college men of the type described in this committee's first report on page 168 of the Proceedings, Vol. 42, for 1941.

2. This demand is to be expected because the railways must be in a position to meet the future needs for employees qualified for advancement.

3. The railways have not as yet reflected this demand to the same degree as other industries or to the extent to which they are justified, but they are now showing increasing interest.

4. Colleges are prepared to cooperate with the railways in supplying the men qualified to meet this demand.

5. The services of your committee appear to be very opportune at the present time in that they should serve to remove any misapprehensions on the part of educators and students and should develop the needed cooperative relationship between the colleges and the railways.

Report on Assignment 4

Stimulate a Greater Interest in the Science of Transportation Among University and College Students

and Create Thereby a Greater Appreciation of the Place of Transportation in Our National Economic Structure, Cooperating with Organizations of University and College Students and Contributing to Their Activities in Such Manner as May be Mutually Arranged

W. C. Sadler (chairman, subcommittee), Lem Adams, F. T. Darrow, W. D. Faucette, P. M. Gault, Clark Hungerford, R. B. Kittredge, F. A. Russell, F. S. Schwinn and C. C. Williams.

Your committee submits the following report as information.

It is of considerable importance to the universities and to the railroads that college students have a greater appreciation of and interest in the railroad industry. It is axiomatic, however, that this interest should be developed purely on the merits of the case. The advantages and promises of railroad employment are many; and, on the other hand, college students possess unusually attractive qualities for rendering successful service in this field.

The main means for developing college interest in railroad work lies in the disclosure of the facts pertaining thereto. This may be accomplished in a number of ways, such as through summer employment, campus meetings, inspection trips, and libraries,

Probably the most effective of these is summer employment. This work should be varied, with successive summers devoted to different departments, if possible. It would seem to be particularly desirable that the first summer be spent on track maintenance as the student is then given opportunity to gain much fundamental experience in ways of doing things and in handling men. This experience will teach him thoroughness and perseverance, and will give the point of view of his fellow workmen. It will also develop in him a rather keen sense of what constitutes an honest day's work. Such knowledge will be of real value both in the consideration of labor problems in the future and in the normal routine of estimating in the division office. Successive summers in the signal department, in a yardmaster's office, and in the accounting and auditing department, are very desirable, for even the most robust, efficient field man should have an appreciation of the clerical work behind his job.

Students as a class have a high sense of appreciation. Undergraduates have considerable difficulty in securing summer jobs; but when they do, they develop an unusual loyalty toward their employer. Summer employment of college students will have the very natural result of increasing railroad good will. This summer employment offers an opportunity, also, for a practical tryout period, with advantages to both the employer and the employee.

Unfortunately, many railroads interested in participating in summer employment have assumed the rather altruistic or sympathetic attitude of merely helping out a needy student, completely ignoring the potential advantages to themselves. The passing of the old necessitates training of the new. In view of this fact, much of this summer employment has been rather haphazard in character, without a definite constructive policy. It is believed that a definite program is absolutely necessary. It is encouraging, however, to note that certain roads are coming to appreciate the value of well-directed summer employment of college students and are formulating definite procedures for selecting such men, for placing them in their organizations, and for watching their progress as a means for determining their desirability as permanent employees after their graduation.

Meetings of student societies have always been popular in campus areas. Railroad officers should appreciate this fact and even take the initiative in offering their services to appropriate campus societies. An interesting, constructive talk by a railroad officer, with illustrated comments on modern developments, characteristics of service, etc., is not only vital to awakening an interest in the prospective railroad employee, but is equally valuable also to the vast majority of the students, some of whom will be very substantial shippers of freight in the future. For a number of years, the Associated Traffic Clubs of America maintained a list of volunteer speakers, and the railroads might well develop a similar service.

College inspection trips have always been a very popular means of showing students the nature and diversity of railway problems and practices and thereby interesting them in railway service as a career. While the railways are now working under special pressure, there are few which cannot spare the time necessary to extend this cooperation, recognizing that this may constitute the means for attracting some capable, ambitious young men to their industry and perhaps to their railroad. The railways can afford to give increased attention to this means of arousing interest in their operations.

Attention is again called to the desirability of having complete sets of AREA proceedings in engineering college libraries. It is recommended that the Association, through this committee or its secretary, ascertain the demand among the colleges for this fine reference material, and also ascertain the availability of this material among older members of the Association.

Report of Committee 27—Maintenance of Way Work Equipment

G. R. Westcott, *Chairman,*
G. J. Adamson
C. M. Angel
R. M. Baldock
Edgar Bennett
G. E. Boyd
G. T. Donahue
G. J. Ermentrout
C. L. Fero
J. G. Hartley
H. C. Hayes
L. B. Holt
N. W. Hutchison
E. C. Jackson
R. K. Johnson
W. G. Kemmerer
C. R. Knowles
Jack Largent
R. M. Leeds
R. W. Marye
F. H. McKenney
E. H. Mills
C. E. Morgan
R. A. Morrison
C. H. Morse
A. J. Neff
E. H. Ness
C. H. R. Howe, *Vice-Chairman,*
C. H. Ordas
P. G. Petri
T. M. Pittman
W. D. Rhoads
F. H. Rothe
J. C. Ryan
R. R. Smith
J. L. Starkie
S. E. Tracy
Roy Wade
F. F. Zavatkay
Committee

To the American Railway Engineering Association:

Your committee reports on the following assignments:

1. Revision of Manual.
   Progress report, including recommended revisions ..... page 188
2. Standardization of parts and accessories for railway maintenance motor cars.
   Progress report, with plans submitted for adoption ..... page 189
3. Lubrication of roadway machines.
   Final report, presented as information ..... page 193
4. Self-contained, direct-blow gasoline tampers.
   No report.
5. New developments in roadway machines.
   Progress report, presented as information ..... page 206
6. Color of roadway machines.
   Final report, presented as information, with conclusions submitted for adoption ..... page 211
7. Push cars and trailer cars.
   Final report, presented as information ..... page 213
8. Mowing machines.
   No report.
9. Wire rope used with work equipment.
   No report.
10. Railway owned automotive equipment.
    No report.

11. Power spike pullers.

No report.

12. Weed burners and extinguisher cars.

No report.

13. Safety devices for work equipment, collaborating with Committee 22—Economics of Railway Labor, and the Safety Section, AAR.

No report.

14. Power and bonding drills.

Final report—presented as information ..... page 218

THE COMMITTEE ON MAINTENANCE OF WAY WORK EQUIPMENT,
G. R. WESTCOTT, *Chairman.*

Report on Assignment 1

Revision of Manual

C. H. R. Howe (chairman, subcommittee), G. E. Boyd, N. W. Hutchison, C. R. Knowles, R. A. Morrison, C. H. Morse, J. L. Starkie.

The committee recommends the following revisions of the Manual:

(a) Elimination of forms 2701 to 2704 inclusive. These are report forms covering the inspection cost of operation, repair and retirement of motor cars.

(b) Recommend in lieu thereof the insertion of forms 1 to 6, inclusive, as published in Volume 40 of the Proceedings.

(c) The committee also recommends the insertion of forms A to L, inclusive, as published in Volume 42 of the Proceedings. These are forms concerning the recording of data essential to the economical operation and maintenance of all types of roadway equipment.

The committee recommends changes in the wording of the following definitions appearing on page 8 of the Glossary under the heading "Car":

PUSH.—A four-wheeled railway work car designed to be pushed by hand, or towed by a motor car, and employed for transporting materials too heavy to be carried on a motor or level car. (hand car)

TRAILER.—A four-wheeled railway work car similar to a push car but equipped with a seat, foot boards, safety rails and brakes, employed in conjunction with a motor car, for transporting men. It may be converted into a push car by removing the seat, foot boards and railings.

Report of Assignment 2

Standardization of Parts and Accessories for Railway Maintenance Motor Cars

R. K. Johnson (chairman, subcommittee), G. J. Ermentrout, W. G. Kemmerer, C. H. Morse, E. H. Ness, C. H. Ordas, P. G. Petri, S. E. Tracy, Roy Wade.

This is a final report, including three plans that are offered for adoption.

During the past several years, motor car wheels of the demountable type have become available and offer many advantages. Generally wheel renewals are made necessary by the wear on the tire. The use of a tire that can be renewed independently of the hub makes it unnecessary to pull the wheel from the axle, thus the gage is not disturbed, nor is it necessary to renew the insulating bushing. The tires can be had at less cost than the entire wheel and less metal is scrapped in making the renewal. The labor involved is also less.

In order that there may be interchangeability of parts, it was the thought of your committee that a design showing the dimensions necessary for interchangeability was desirable. In developing this design present practices of manufacturers have been followed as closely as consistent with interchangeability. The plan is shown in Fig. 1.

In connection with the design of the demountable wheel, certain changes in Fig. 2704 Revised, now in the Manual, showing the recommended standard axle, became desirable. These were specifically—

A change in length of taper on the ends of the axle.
The fixing of the location of the cotter pin hole in the ends of the axle.
The elimination of the note indicating how the gage of wheels other than standard may be secured.

With a proper split bushing ⅛ in. thick, nearly any practical variation from standard gage that might be desired can be obtained without change in the effective length of the axle. The revised plan is shown in Fig. 2.

Fig. 2703 now in the Manual shows a safety rail for maintenance motor cars that was designed at a time when many direct-connected cars were in use and rear rail was accordingly limited to the width of the seat deck, that men starting the car by pushing could mount the car after it was in motion. Under rules now commonly in use, the mounting of moving cars is generally forbidden and it was the consensus of the committee that a full width rail at the rear of the car would give added safety. Also, it was thought desirable that both front and rear rails should be more strongly supported. These changes are shown in Fig. 3.

The following are therefore offered as recommended for adoption and publication in the Manual:

Fig. 1—16-in. and 20-in. bolted demountable plate wheel using ⅛-in. insulating bushing for motor cars with $1\frac{7}{16}$-in. axles.

Fig. 2 (Superseding Fig. 2704 Revised) $1\frac{7}{16}$-in. axle (Normal 1½-in.), and ring gage for checking axle dimension on maintenance motor cars.

Fig. 3 (Superseding Fig. 2703) safety rails for maintenance motor cars.

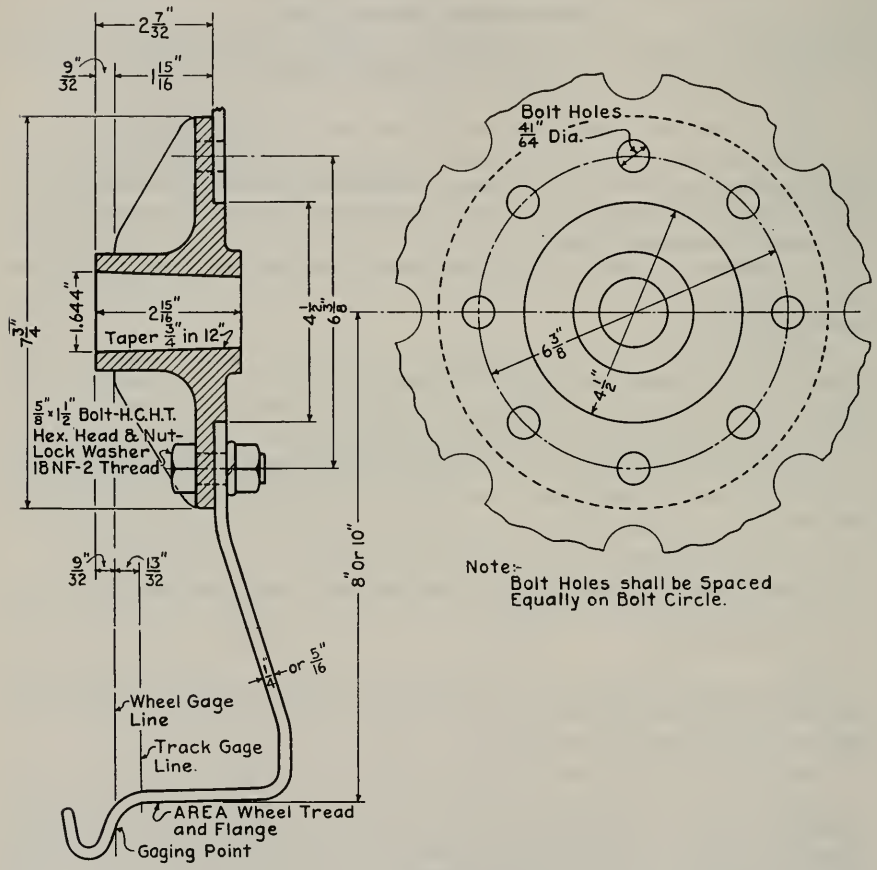


Fig. 1.—AREA 16-in. and 20-in. Bolted Demountable Plate Wheel, Using ⅛-in. Insulating Bushing for Motor Cars with $1\frac{7}{16}$-in. Axles.

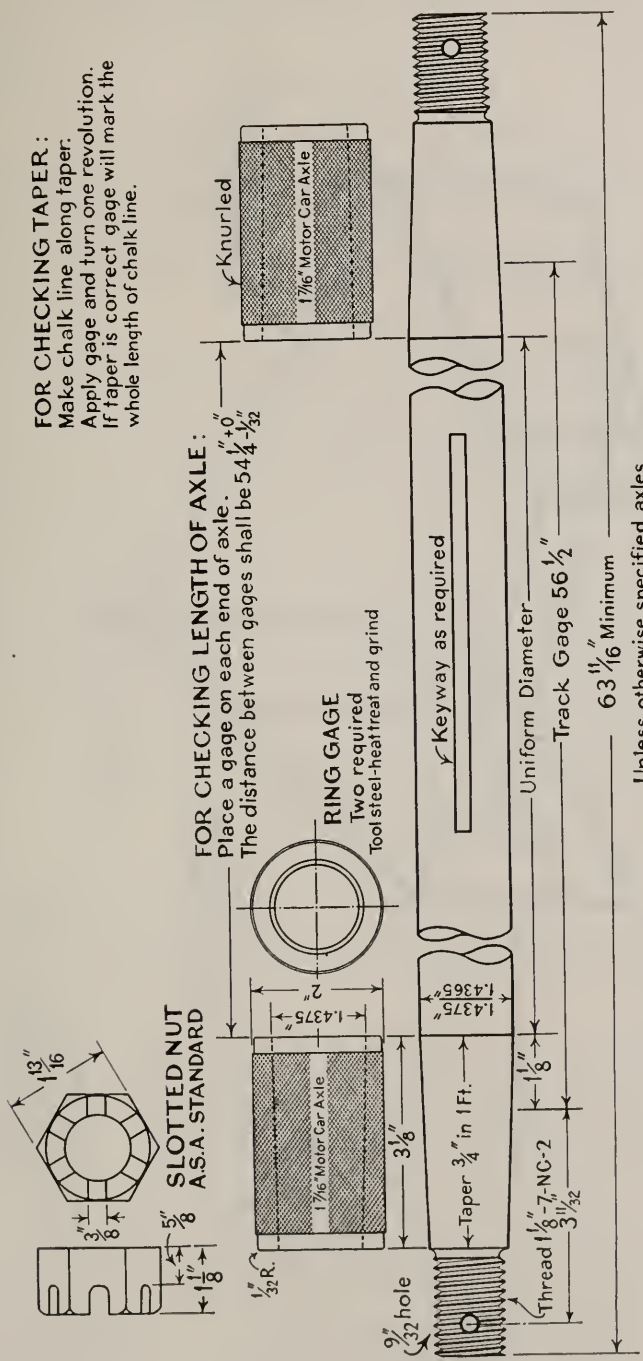


Fig. 2.—AREA 1½-in. Axle and Ring Gage for Checking Dimensions for Maintenance Motor Car Axles.

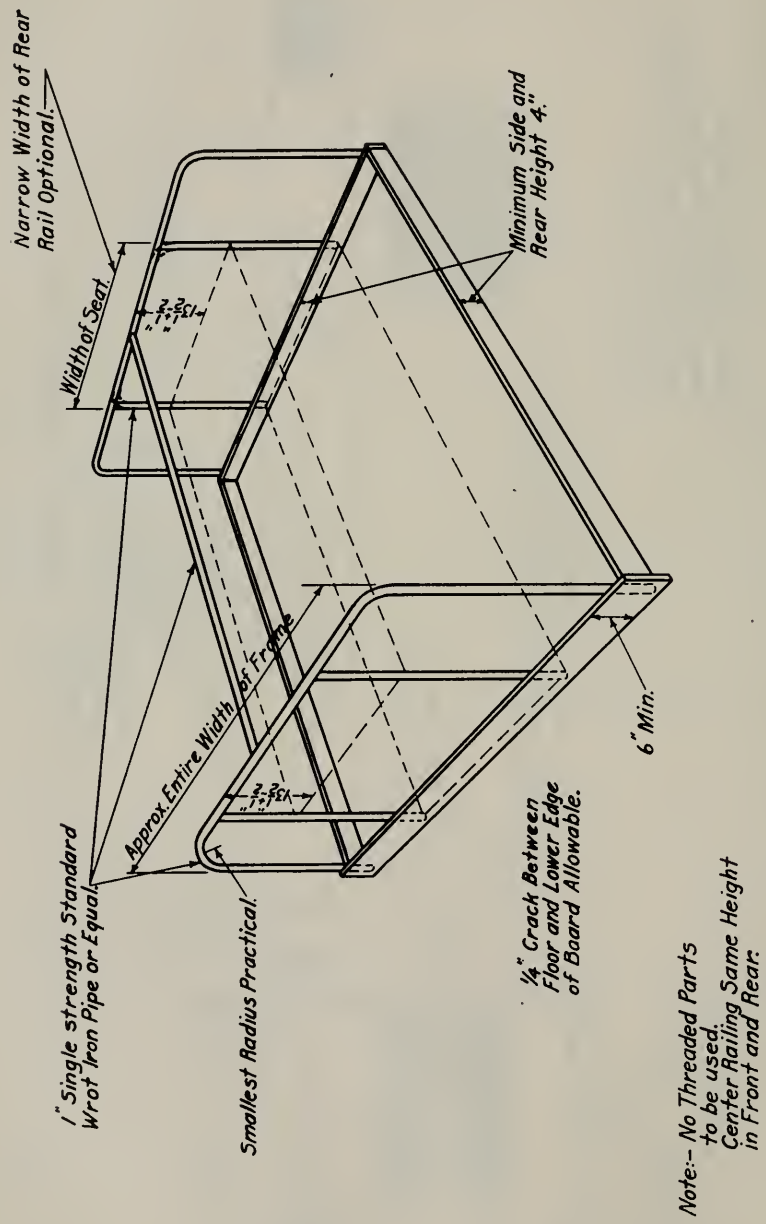


Fig. 3.—Safety Rails for Maintenance Motor Cars.

Report on Assignment 3

Lubrication of Roadway Machines

C. M. Angel (chairman, subcommittee), C. H. R. Howe, E. C. Jackson, R. W. Marye, E. H. Mills, C. H. Ordas, J. C. Ryan, S. E. Tracy, Roy Wade.

This report is submitted as information with the recommendation that the assignment be discontinued.

Introduction

The story of the history and evolution of lubrication has been told many times for the purpose of providing a foundation upon which to build an understanding of the subject. However, in the final analysis a lubricant is a material whose function is to separate two adjacent moving surfaces, thereby reducing frictional resistance. The petroleum industry, as in the past, is continually conducting campaigns of research to secure the proper lubricant for each specific case, so that valuable service will not be lost due to improper lubrication.

To use lubricants economically, it is necessary for the users to have an accurate understanding of their source and nature. However, it is difficult for the layman to determine relative values, as the qualities of lubricants are generally expressed in various technical terms and chemical descriptions. An explanation of terms, and all general information on the subject should be valuable to those in charge of the lubrication of equipment. When the maintenance of way department began to motorize its work equipment on a large scale, lubrication became of major importance to that department.

This report is presented as an analysis of some of the problems of lubrication; and if those interested in oils and greases familiarize themselves with the fundamentals outlined, they will gain a clearer understanding of the subject and a knowledge of the essential properties to be considered when selecting a lubricant.

Oils, Greases and Crude Petroleum

It should be remembered that there is a close relationship between lubricating oils and greases and crude petroleum because lubricating oils are secured from petroleum by distillation or other methods. When secured by distillation, gravities are taken at various temperatures; and these may vary from water fluidity to products akin to syrup at room temperatures.

Grease is a semi-solid combination of lubricating oils and a soap, or a mixture of a soap with or without fillers. Some of the fillers used are lime, soda, aluminum and lead.

Petroleum crude, or mineral oil, from which lubricants are derived is composed almost entirely of carbon and hydrogen; those from the Pennsylvania and Ohio fields contain wax and are known as paraffin base oils; whereas crudes from the Gulf Coast and California contain asphalt and are termed asphaltic or napthalene base oils. The mid-continent oils have a mixed base composition.

There are other oils which are termed fixed oils such as those of animal or vegetable origin that cannot be distilled without decomposition, the most common being lard, tallow, rape seed, colza, castor and sperm. These oils contain oxygen as well as carbon and hydrogen.

Under Appendix A, of this report will be found a brief glossary of lubricating terms, an approved test of lubricants, and a description and explanation of straight and

blended oils, and their combination with soap and fillers to form greases. In Appendix B an explanation is given of common questions which arise in connection with lubricating work.

Lubricants Cannot Be Standardized

Before discussing the qualities of a serviceable lubricant, it is necessary to answer the question as to why a lubricating oil or grease for a piece of work equipment after once adopted cannot be standardized for all railroads. As each section of the country has a different crude petroleum base it would be more economical to use a lubricant from a crude oil supply convenient to the point of use rather than from distant locations.

Service tests will give facts as to the desirability. of a lubricant for the purpose intended; however, the human element of personal preference has a considerable effect on the choice of the lubricant. That is, where two or more oils give satisfactory service, the same oil will not always be selected by different individuals. Atmospheric temperatures in the various sections of the country also govern the lubricant used.

The difference in the various lubricants used over the country for work equipment was illustrated by analyzing the replies received from questionnaires sent to the maintenance of way departments of a large number of railroads. In many cases each railroad used either a different brand, or grade of lubricant for similar machines at various locations.

In Table 1 is given a comparison of properties of gas-engine oils used respectively by one western, one northern, and one southern railroad in work equipment motors; and it will be noted that there is a range of difference even in the standard numbers of oils in these three sections of the country. Table 2 shows the composition of greases used by two railroads in the same section of the country.

Therefore, from the foregoing, it can readily be seen that standardization of lubricants is not possible; their selection should be based on service tests, with specified qualifications to meet the conditions of operation and temperature of the machine to be lubricated.

Proper Selection of a Lubricant

In the selection of a lubricant due consideration should always be given to economy; that is, the lubricant which will give the best average friction reduction at the most economical cost. The important considerations may be summed up as follows:

1. The equipment to be lubricated
2. Safe operation.
3. Confidence in the refiner from whom the lubricant is secured

Having in mind the various crudes from which lubricants are obtained, and the properties and chemical terms used, it is important then to give consideration to the properties and chemical composition which are desirable when selecting a lubricant. These are as follows:

1. Proper viscosity to keep the surfaces apart under maximum pressure
2. Small carbon residue
3. Pour point
4. Separation from emulsion
5. Low coefficient of friction
6. Capacity for absorbing and carrying away heat
7. Freedom from tendency to oxidize or gum

TABLE 1—COMPARISON OF REQUIREMENTS OF GAS ENGINE OILS USED BY ONE WESTERN, NORTHERN AND SOUTHERN RAILROAD IN WORK EQUIPMENT MOTORS

	Western Railroad					Northern Railroad							Southern Railroad					
Grade	*A*	*B*	*C*	*D*	*E*	*SAE 10*	*SAE 20*	*SAE 30*	*SAE 40*	*SAE 50*	*SAE 60*	*SAE 70*	*SAE 10*	*SAE 20*	*SAE 30*	*SAE 40*	*SAE 50*	*SAE 60*
Gravity (min.) deg. API	28.5	28.5	28.5	28.5	28.5	23	23	23	23	23	23	25	29.5	28.5	27.5	26.5	26.0	25.5
Flash min. deg. F.	385	420	435	450	440	350	360	375	400	435	475	490	390	415	430	445	475	490
Fire min. deg. F.	440	470	495	520	500													
Carbon residue max. %	0.35	0.35	0.70	0.90	0.90	0.15	0.25	0.35	0.65	1.0	1.3	1.4	0.10	0.20	0.28	0.35	0.55	0.70
Pour point max. deg. F.	0	0	20	20	40	0	0	0	25	30	15	30	0	0	5	10	15	20
Max. neutralization																		
Number Mg—KOH—	0.10	0.10	0.10	0.10	0.10													
Viscosity at 210° F. min. sec.	46	60	80	100	75				65	75	97	115	44	53	63	75	95	115
Viscosity at 210° F. max. sec.	49	65	85	105	80						105		49	58	68	80	105	125
Viscosity at 100° F. min. sec.																		
Viscosity at 100° F. max. sec.									700	800	1500	1500						
Viscosity at 130° F. min. sec.						90	120	185										
Viscosity at 130° F. max. sec.						120	185	255										
Precipitation number max.																		
Viscosity index min.	90	50	50	50	75								80	80	80	80	80	80
Viscosity index method	D&D	D&D	D&D	D&D	D&D								D&D	D&D	D&D	D&D	D&D	D&D
Standard method of tests	ASTM	ASTM	ASTM	ASTM	ASTM								ASTM	ASTM	ASTM	ASTM	ASTM	ASTM
Corrosion test copper strip						Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

Reference:
- D&D—Dean and Davis
- ASTM—American Society for Testing Materials
- SAE—Society of Automotive Engineers
- Neg.—Negative
- Carbon Residue—Conradson Method
- API—American Petroleum Institute
- Viscosity—Saybolt Universal

TABLE 2—COMPOSITION OF GREASES USED BY TWO RAILROADS ON WORK EQUIPMENT

Type of grease	*Cup*	*Cup*	*Cup*	*Cup*	*Cup*	*Cup*	*Cup*	*Cup*	*Cup*	*Cup*	*Press Gun*	*Ball Bearing*
Specification or grade												
Identification (A)	3	4	1	2	3	1	2	3	4	5	Loco	495-A
Oil stock	Mineral	Mineral	Cyl. Stock	Cyl. Stock	Cyl. Stock	Mineral	Mineral	Mineral	Mineral	Mineral	Mineral	Mineral
Viscosity Oil 100° F. Min. Sec.	100	100				100	100	100	100	100	900	
Viscosity Oil 100° F. Max. Sec.											2800	
Viscosity Oil 210° F. Min. Sec.			140	140	140						80	54
Viscosity Oil 210° F. Max. Sec.			160	160	160						100	55
Flash of oil used deg. F. Min.											400	
Pour point of oil used											+20° F.	0° F.
Viscosity index of oil used											90	
Soap content percent Min.			9.5	14.0	20.0	11	13	16	20	23	9	
Soap content percent Max.	18	21	10.5	16.0	22.0	13	15	18	22	25	17	
Moisture content percent Min.						1	1	1	1	1		
Moisture content percent Max.	3	3	0.5	0.5	0.5	3	3	3	3	3	1.5	0.20
Ash content percent Max.	2.3	2.9				1.5	1.7	2.0	2.3	2.5		
Corrosion copper strip 24 hrs.	Negative	Negative				Negative	Negative	Negative	Negative	Negative		
Fillers	None	None				None	None	None	None	None		
Melting point min. deg. F.	197	205										
Alkalies percent Max.			0.25	0.25	0.25						0.20	0.20
Acid calculated as oleic acid			0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	None	None
Unsaponified fat percent			1.0	1.0	1.0							
Flake graphite may be added percent						5	5	5	5	5		
Sands, silicates percent						.03	.03	.03	.03	.03		
Lime used to contain less than percent magnesium oxide						5	5	5	5	5		
Worked penetration min.											265	
Worked penetration max.											320	
Method of test											ASTM	

(A) Railroad identification
Viscosity—Saybolt universal
Viscosity index—Dean & Davis
ASTM—American Society for Testing Materials

8. High flash point or temperature at which vaporization takes place
9. Freedom from corrosive acids
10. Freedom from abrasives

Only a few of the above oil properties are required for a given operating condition; however, those necessary for specific applications should always be considered.

Viscosity is a very important factor to consider in the selection of a lubricant. The viscosity changes vary greatly with changes in temperature. Two things should be remembered in connection with viscosity. First, viscosities of oils are generally measured at standard temperatures of 100 deg. F., 130 deg. F., and 210 deg. F. Second, all oils do not change in body at the same rate between two temperatures. One oil may get thicker at lower, or thinner at higher temperatures than another oil. The term viscosity should not be misunderstood; it is not the indication of the lubricating value of an oil, but merely shows the fluidity at a given temperature.

Oils used should have as low a carbon residue as possible. The carbon residue is produced when oil is decomposed by heat in the presence of air. Two types of carbon are found in oil; one which forms a quantity of soft fluffy carbon will leave a little deposit as it is blown out with the exhaust while another will burn to a small amount of hard flinty carbon which may be injurious. In considering an oil from the carbon residue standpoint, one should not be misled into thinking that the material which sticks the rings and gums the pistons is due altogether to the carbon residue of an oil; this is often attributable to incomplete burning of the fuel.

The pour point is important as it is the lowest temperature at which an oil will flow from a receptacle without assistance.

It is always desirable to use an oil of a high flash and fire point; however, these have only a limited relation to the lubrication functions.

The emulsion characteristics of the oil are important when the lubricant must come in contact with moisture or steam.

The grease selected should be as free as possible from acid forming tendencies to insure adequate protection to highly polished metallic surfaces and should not contain any materials that might give rise to oxidation, decomposition or settling.

The penetration number, or the measure of the consistency of the grease is important, so that after a grease of proper consistency is selected, a check on it can be maintained as long as it is being purchased.

For semi-grease or stiff oils the Furol viscosity (Saybolt–Furol Viscosimeter) is necessary in controlling the use of this type of lubricant.

Grease should not contain any fillers or abrasives which would affect the highly polished metallic surfaces.

Therefore, in selecting a lubricant it is necessary to determine the comparative values of the various lubricants suggested, for the purpose intended, and having the desired properties suited to actual operating conditions.

Testing to Approve an Oil or Grease for Service

Before approving a lubricating oil or grease which is to be covered by specifications, it is important that the lubricant be given both laboratory and service tests. The laboratory tests (chemical and physical tests) are usually made by the refiner to ascertain the lubricating properties of the lubricant and compared on the basis of the latest test methods which govern the standards upon which lubricants are graded. These tests determine gravity, color, pour point, flash, fire, viscosities, neutralization number, rate of oxidation and many other criteria by which modern oils are judged.

Laboratory tests should not be considered as final or conclusive, but a service test should be conducted in comparison with a lubricant which is giving fairly good service. This will strengthen the decision for the adoption of the lubricant. The primary purpose of the service test is to determine, under actual operating conditions, the non-technical comparative viewpoint rather than a highly specialized laboratory point of view. This test is the final proof of the value of the product and should determine acceptance or rejection by the consumer.

Service tests may be so complicated as to involve the analysis of a large amount of test data, or they may be relatively simple and provide just enough information to afford the basis for a decision from the viewpoint of the user. To illustrate: Two grades of motor oils are to be tested in a motor driven appliance. Technically the motor could be placed on a block and run at various speeds, with different brake loads, etc., and considerable test data accumulated; however, the simpler plan would be to test the oil under actual operating conditions in the following manner:

Two motors in the same service could be used for the test, each using the same test oil throughout the test period.

Before the start of the test both motors are completely overhauled and accurate measurements taken of all wearing parts. The carburetors after once being adjusted should not be changed during the test period, unless it is very necessary to do so, as a change in the carburetor may be reflected in the oil consumption.

The oils to be tested are analyzed for their chemical properties, so a complete record will be had of the oil before use.

At the start of the test a predetermined mileage or hours of service should be set up for the oil changes; however, after the first analysis of the changed oil this mileage or hours of service can be extended or reduced if the condition of the used oil shows a change is necessary. A better plan is to take a sample of oil from the crank cases from time to time, and from the analysis determine when the oil change should be made.

The oil and sludge removed from the crank case after being used should be analyzed; the oil, for gravity *API,* flash point, fire point, viscosity at 210 deg. F., pour point deg. F., carbon residue and precipitation number; the sludge, for matter volatile at 105 deg. C.; oil content (petroleum ether extraction); tarry matter (benzol extraction), ash and carbonaceous matter.

After completion of the test, the engines are dismantled and measurements taken of the wearing parts and compared with the original measurements to ascertain the wear.

From the chemical analysis, wear, and oil and gasoline consumption records, a decision can probably be rendered for or against the lubricant being tested. In many cases, long before the end of the established test period, the oils may be accepted or rejected by visual observation.

The test of a grease also may be divided between laboratory tests and service tests to ascertain if the grease is suitable for the purpose for which it is to be used. The laboratory work is ordinarily confined to chemical analysis, but there has been some movement toward the development of machines for testing the behavior of greases under conditions paralleling actual service from the angle of breakdown. In the testing of greases as a general rule, appreciable thickening, separation or oxidation can be noted if the grease begins to break down, or a reduction in lubrication value occurs.

The service test is conducted under actual conditions, in a similar manner to that outlined for the test of oils on a comparative basis. Factors should be developed whereby one grease can be contrasted with another by the rate of change in its physical and chemical characteristics.

In the test of grease in ball or roller bearings, one of the most frequent causes of bearing failures is the practice of forcing an excessive amount of grease into the housing by means of a pressure gun or compression cup. That should be watched closely in the test of greases in roller or ball bearings, as the expansion of the heated grease might be sufficient to crack the housing.

A conclusion with respect to an oil or grease should be based on a correlation of the data from the laboratory tests, chemical analysis, and service tests. However, the economic value should not be overlooked; another lubricant at a lower cost may not give quite as good service but may still serve the purpose under the operating conditions imposed.

Oil and Grease Specifications

It is customary when delivering new equipment for the manufacturer to furnish a list of typical greases and oils for the lubricating of the machine. Sometimes, due to conditions beyond the purchaser's control, it is impossible to secure these greases and oils, and an effort is made to obtain others with as near their characteristics as possible. If specifications are prepared for this purpose, they should be brief; and particular emphasis should be placed on the service clause, so that it will be possible to judge the lubricant under actual service conditions.

The specifications should cover the chemical characteristics of the greases or oils, and such physical properties as viscosity, flash, fire points, corrosive action, etc., and the penetration test and number of the grease desired.

No attempt should be made to specify the manner in which the refiner should blend the viscosity of the oils, or compound the grease furnished, as each refiner employs methods based on refinery experience and research with the petroleum base used.

Outline for the Preparation of Specifications for Oils and Greases

Oil Specification No. (Type of Oil)	*Grease* Specification No. (Type of Grease)
Scope—Covers grade of oil desired.	Covers grade of grease desired.
Quality—Describes oil, such as mineral oil free from animal or vegetable oil, etc.	Describes grease, no filler such as tallow, powdered mica, etc.
Properties—Physical and chemical tests, such as flash point, pour point reaction, etc.	Tests such as penetration, mineral oil, soap content, free alkali, etc.
Service test—Designed to test the oil under actual conditions.	Designed to test grease under actual conditions.
Packing—Description of containers.	Description of containers.
Inspection—Right to secure test or analysis.	Right to secure test or analysis.
Rejection—Description of how rejected material should be handled.	Description of how rejected material should be handled.

Sheet No. ....

Exhibit 1—Lubrication Chart (Maintenance of Way)

General		Acct. No.	Ref. No.
Ball and roller bearings with grease fittings	Ball bearing grease		
Ball and roller bearings with oil fittings	Heavy engine oil		
Cables	500-deg. oil		
Finished parts exposed to weather when out of service	Slushing oil		
Grease cups except water pump shaft bearings	Cup grease No. 3		
Gear and transmission housings, summer	Differential grease, heavy		
Gear and transmission housings, winter	Differential grease		
Hydraulic jacks and locks	Neutral oil		
Journals on cars, cranes, spreaders, etc.	Coach engine oil		
Open gears	Gear compound		
Pins, clevices, levers, etc., on brake or similar mechanism	Crank case drainage		
Roller chains and sprockets, when required	Differential grease		
Side bearings and center plates on cars, cranes and spreaders	Center plate grease		
Master track lubricators	Grease		
Meco track lubricators	Grease		
Internal Combustion Engines (Gasoline or Fuel Oil)			
2-cycle air or water cooled: ½ pint of oil per gallon of gasoline	Heavy engine oil		
4-cycle air cooled, winter	Medium engine oil		
4-cycle water cooled, winter	Light engine oil		
4-cycle water or air cooled, summer	Heavy engine oil		
Magnetos, starting motors and generators	Same oil as used on engine		
Water pump shaft bearings	No. 5 Cup grease		
Crank case lubrication, extremely cold weather	Compressor oil		
Steam Engines, Pumps and Hammers			
Air pump cylinder and valves, air end	Compressor oil		
Cylinders and valves	Cylinder oil		
Crank shaft and pin bearings with grease fittings	No. 3 Cup grease		
Oil cups, valve guides, piston guides, etc.	Cylinder oil		
Turbines	Turbine oil		
Electric Generators and Motors			
Commutators, collector rings, contact fingers, etc.	Petrolatum		

Any other information pertaining to the lubricant should also be added to the specification.

Lubricating Charts and Instructions

After proper lubricants have been approved for work equipment, these oils and greases should be listed on some type of form for convenient reference in the field. The form used should show the type of grease, or oil, and the equipment part on which it is to be used. It also should set forth clearly any specific instructions to be used in connection with the lubrication of any of the equipment listed.

Such a form will be a matter of personal selection, governed largely by the desires of those preparing the instructions; however, two forms are shown under Exhibits 1 and 2 which will give some idea as to the method, imparting such information to those directly handling the lubrication of the equipment.

Exhibit 2

LUBRICATION CHART

Railroad

Maintenance of Way Department

Equipment	Parts to be Lubricated	Recommendations of Lubricants

Conclusion

Your committee, in preparing this report, has endeavored to reduce to simple treatment, in relatively brief form, the many details involved in the lubrication of work equipment. Also, care has been taken to present the simple and fundamental facts with accompanying explanations.

There can be no standardization of grease and oils because the selection of a lubricant may be governed by basic differences in the crude oil reserves available in various locations, differences in refining processes and differences in climatic conditions. Therefore, lubricants should be selected on the basis of service and laboratory tests, giving due consideration to the chemical properties.

In the selection of a lubricant, it is necessary to give consideration to the following requirements:

1. It must maintain an unbroken oil film between the moving lubricated parts if it is to prevent wear on the surface of bearings.
2. It must prevent excessive generation of heat which would otherwise be created by friction.
3. It must carry away heat developed during operation in order that the bearing may be operated at the lowest possible temperature.

Finally, in the selection of a lubricant the subject of economy should be given due consideration; that is, the cost of a lubricant for the purpose intended.

Appendix A

Glossary of Lubricating Terms, Oil and Grease, Their Properties and Tests

"Red Oils.—Originally the residual fraction obtained by fire-distilling pressed distillates, acid treated but not filtered; at present, any oil of red color regardless of refining process. The bulk of the so called red engine oils, bearing oils, and machinery oils are of this class. An intermediate grade of lubricating oil for general purpose.

"White Oils.—Treated with fuming sulphuric acid or otherwise decolorized completely. They are easily made from Russian crudes and are widely used in bakeries and food preparation plants. These oils are seldom made from paraffin base crudes as it is difficult to remove all the coloring from these oils.

"Airplane Engine Oil.—Heavy-bodied high quality oil ranging in viscosity from about 80 to 140 SSU at 210 deg. F. They may be pure mineral oils, or mineral oils to which agents have been added. They are produced from bright stock by a solvent extraction process.

"Automobile Engine Oils.—Medium-bodied, usually blended oils, which vary from low to high quality. Many automobile oils contain addition agents. They are usually marketed according to SAE classification numbers.

"Crankcase Oils.—Originally for use in steam engine crank cases, but today the term frequently describes an oil in the crank case of any machine. Specifically these oils are high quality, heavy bodied, pure mineral residuals, having a viscosity of about 100 SSU at 210 deg. F.

"Diesel-Engine Lubricating Oils.—High quality, medium and heavy bodied oils, varying in viscosity from about 600 to 1,600 SSU at 100 deg. F. May contain addition agents and frequently they are solvent refined.

"Transmission Oils.—Vary widely in viscosity and quality. Steam-turbine oils, engine oils, cylinder oils, dark lubricating oils, heavy viscous, tacky residual oils, are used for various purposes depending on the type, design method of lubrication and operating conditions.

"Valve Oils.—Steam cylinder oils, especially lighter bodied, heavier compounded ones."

Lubricants have characteristics which are required for different operating conditions; these are given and described as follows:

Gravity.—The gravity of an oil has no relation whatsoever to the ability of an oil to lubricate, cool, seal or scavenge. Gravity is only useful in determining the volume or weight of oil for storage or shipping. All specific gravity tables are based upon the ratio of the weight of a volume of oil with the same volume of water. The most widely used of these tables for oils are Baumé and the American Petroleum Institute. These tables take into consideration the expansion and contraction of various oils from 60 deg. F.

Color.—Is of no value in determining the lubricating value, source or quality of the oil. A good many years ago it gave roughly an indication of the source of crude from which the lubricant originated. Chemical research today has placed the refiners in position to make oils of any color they desire irrespective of the source and color of the crude.

Pour Point.—The pour point of an oil indicates the lowest temperature at which an oil will perceptibly flow from a receptacle without assistance.

Viscosity.—Is a measure of resistance to flow, and together with oiliness constitutes what is known as the body of an oil. The Saybolt viscosimeter is used for measuring viscosity and consists of a small standard tube at the bottom of a reservoir, all surrounded by a temperature regulating bath. When conditions are stable, the cork is removed, and the oil flows through the orifice into a glass beaker. The time in seconds required for 60 c.c. of oil to flow into the glass is taken as the Saybolt seconds viscosity.

For stiff oils (usually not lubricating oils) the Saybolt–Furol viscosimeter, which has a large tube opening, is used for accurate measurement. The time for stiff oils measured on the Saybolt-Furol is approximately ten times that obtained on a Saybolt Universal Viscosimeter. All viscosity measurements must be made at a definite temperature, as the viscosity number decreases with increase in temperature. Unless the temperature at which the reading is made is known, the viscosity number reveals little. Universal readings are generally taken at 100 deg. F., or 130 deg. F., sometimes at 210 deg. F.

"Relative Viscosity.—Viscosity of a liquid in terms of the viscosity of some other liquid arbitrarily chosen as a standard. The viscosity of distilled water at 20 deg. C. is most frequently used as standard. For example, the absolute viscosity of distilled water at 20 deg. C. is 1.005 centipoises and that of castor oil is 986 centipoises; the relative viscosity, therefore, of castor oil is 986 ÷ 1.005 = 981.

"Specific Viscosity.—Relative viscosity, particularly where the viscosity of water at 20 deg. C. is the standard.

"Viscosity Index.—Relationship between viscosity changes of various oils with given changes in temperatures. The perfect oil, as far as viscosity is concerned, would be one having a constant viscosity regardless of temperature. No such oils exist; all thin out (have lower viscosity) at high temperature, and thicken (increase in viscosity) at low temperatures. Changes in viscosity with temperature change are not the same for all oils. Some thin out more or thicken less than others for a given temperature change. Specifically the 'VI' indicates the relation which the viscosity of an oil at 100 deg. F. bears to the viscosities of an average Pennsylvania oil and an average Coastal oil at that temperature, all three oils having the same viscosity at 210 deg. F.

"Oiliness.—Difference in friction greater than can be accounted for on the basis of viscosity when comparing different lubricants under identical test conditions.

No satisfactory test has been devised for evaluating this property of an oil.

"Lubricating Value.—Frequently used in oil advertisements. It has no specific meaning and no test has been devised for determining it. The U. S. Navy Work Factor test comes as close, perhaps, to evaluating this property of oil as any known test."

Carbon Residue.—The carbon residue of an oil is the carbon produced when a given quantity of oil is decomposed by heat in the presence of a limited amount of air. It has only a limited value in comparing the quality of an oil unless the type of carbon it forms is known. One oil may form a large amount of soft fluffy carbon which will leave little deposit; whereas, another might burn to a small amount of hard flinty carbon, which may be injurious. The deposits which stick or gum piston rings and valves are often attributed to incomplete burning of the fuel, and not to carbon residue.

Sulfur, Neutralization Number and Saponification Number.—These terms are used by oil technologists to evaluate the depreciation of an oil in service. They are also used in controlling the refining processes. They are of little value in indicating the lubricating, cooling, sealing or scavenging ability of an oil.

"Cloud and Pour Points.—Cloud point of an oil is the temperature in deg. F. at which paraffin wax or other solid substances begin to crystallize or separate from solution when the oil is chilled under definite prescribed conditions. Pour point is the lowest temperature at which an oil will pour or flow when it is chilled under definite prescribed conditions (ASTM—designation D 97–34).

"Flash and Fire Point.—(Cleveland Open Cup)—Flash point of an oil is the temperature at which sufficient vapor is given off to form momentarily an inflammable mixture with air when a small flame is applied. Fire point is the temperature in degrees at which this inflammable mixture will burn continuously (ASTM designation D 92–33).

"Film Strength or Load-Carrying Capacity.—Ability of an oil to resist the squeezing action of high unit pressures without complete rupture of the oil film. No single test, method or instrument has been standardized for determining the film strength of an oil."

Penetration Number of Grease.—This test is used to measure the original consistency or worked consistency of greases. It shall not be applied to greases which have been poured and cooled during manufacture.

The consistency shall be determined by measuring penetration on a standard ASTM pentrometer.

The procedure is to place a sample of grease on the pentrometer table and to lower the cone until the tip just touches the surface of the grease. The scale of the pentrometer is set at zero, the plunger released and kept released for 5 seconds. The penetration is read from the scale.

Temperature control is important and the samples should be held within 1 deg. F. of 77 deg. F. before the test.

Five tests shall be made on each sample and the average reported as penetration.

The method of test shall be that outlined in ASTM designation D 217–38T.

The committee wishes to express its appreciation to Professor Clower, associate professor of machine design, Virginia Polytechnic Institute, and Power Magazine for quotations appearing in the above Glossary of Lubricating Terms.

Appendix B

Explanation of Common Questions Concerning Lubrication

QUESTION: Does a high viscosity indicate high fluidity, or is the reverse true?

ANSWER: Viscosity is a measure of fluidity or rate of flow of an oil. Measured in seconds, at definite temperature and through a standard orifice, high viscosity indicates low fluidity and low viscosity indicates high fluidity.

QUESTION: What is the quality in the oil that makes it a good lubricant or a poor one?

ANSWER: The property of oiliness, or maintenance of an oil film to prevent contact of solid surfaces.

QUESTION: Why do some oils make satisfactory lubricants at high temperatures, while others do not?

ANSWER: Refining processes in general do not completely stabilize the chemical composition of oils; this in turn reflects on the ability of the oil to withstand high temperatures without chemical breakdown. A specially refined oil will stand high temperatures, but the source of the crude, the grade and the kind of oil also govern its behavior at high temperatures.

QUESTION: Why do some oils make satisfactory lubricants at very low temperatures, while others do not?

ANSWER: Satisfactory lubricants for low temperatures depend on refinery process which includes removal of wax or congealing hydrocarbons.

QUESTION: Why do oils lose their lubricating qualities after a period of service?

ANSWER: Deterioration due to conditions of service which introduce elements that change either chemical or physical characteristics or both of the lubricant.

QUESTION: What causes sludging; does this affect the lubricating value of oil and why?

ANSWER: Sludging is caused by the formation of products which are insoluble in the oil. This property of an oil is generally accepted as affecting its lubricating value because the products formed are in most cases objectionable from the standpoint of efficient lubrication. Hydrocarbons of the oil, the source of crude, kind and grade of oil also govern its characteristics.

QUESTION: Why are light oils indicated in some cases and heavy oils in others. This does not refer to variations in temperature but to their application to different machines or different parts of the same machine under the same or substantially the same condition?

ANSWER: Conditions of operation usually determine the use of a light or a heavy oil. Working parts of the machinery also govern the choice. The object is to provide an oil with body possessing proper properties of adhesion and cohesion in order that it may have the greatest efficiency.

QUESTION: What is the difference between a light and a heavy oil?

ANSWER: The essential difference is in their physical properties, particularly the viscosity, although other properties also differ. The chemical characteristics differ too, depending on the type of oil and purpose for which it is intended.

QUESTION: Why are oils better lubricants in some cases than greases, and why is the reverse true in others?

ANSWER: Grease is a soap and mineral oil mixture, and the name is commonly applied to all lubricants that are solid at ordinary temperatures. It is not a question of which is the better lubricant; it is a question of which lubricant will best answer service requirements and operating conditions. The adaptability of the lubricant for the purpose intended governs its choice.

QUESTION: What does one mean when he says an oil is worn out?

ANSWER: For all practical purposes the expression "worn out" means an oil is no longer considered suitable for the purpose intended.

QUESTION: Is the chemical composition of a worn out oil the same as that of the oil originally, or is the change purely physical?

ANSWER: The chemical or physical changes depend on the conditions to which the oil has been subjected. High temperatures induce oxidation which is a chemical change. Operating conditions which permit contamination of the oil, create conditions that affect the physical properties. Therefore, most oils undergo both chemical and physical changes, although in many cases, simple filtration of foreign matter will often restore a "worn out" oil to a condition approximating that of a new oil.

QUESTION: What is the Navy Work Factor test?

ANSWER: A machine has been developed by the United States Naval Experimental Station to subject lubricating oils to an accelerated or endurance test wherein operating conditions can be maintained and controlled. The test affords a means for study of various problems of lubrication such as affect on oil of different bearing metals, depreciation of the oil with excessive or scant flow of the oil to bearings, effect of excessive vibration of the journals and possibly the effect of various gases on lubricating oils during operation. The work factor itself is based upon the increase in viscosity, neutralization number, precipitation number and percent of carbon residue of a lubricating oil when subjected to service in the test machine. Numerical differences are incorporated into formulas to arrive at so-called values for the respective tests. The average of these work values is termed the work factor of the oil under test.

Report on Assignment 5

New Developments in Roadway Machines

G. E. Boyd (chairman, subcommittee), R. M. Baldock, Edgar Bennett, C. L. Fero, J. G. Hartley, N. W. Hutchison, E. C. Jackson, A. J. Neff, P. G. Petri, F. H. Rothe, R. R. Smith.

It is recommended that this report be received as information and that the subject be continued.

It requires some effort to realize that the power machines and power tools with which we are familiar today, and which we group under the general term, "maintenance of way work equipment," are, with a few exceptions, a development of the last quarter century, or that not a few men who are still active in railway service have seen the whole development of this equipment. The most notable of the exceptions mentioned are the motor car, the locomotive crane and the pile driver, all of which had reached a considerable stage of development a quarter of a century ago.

While there had been many undercurrents directed toward the development of mechanical aids to maintenance, it was the shortage of labor during the World War that stimulated this activity. The first machines were crude, inefficient and heavy, judged by the standards of today. Engine speeds were low; and fuel consumption was high, while not a few of the units placed on the market were under-powered. In general, little thought was given to safety features; and few of the machines were manufactured

with the proper degree of precision, with the result that parts fitted poorly; operation was often accompanied with unnecessary noise; and maintenance was high. Designs were often complicated; and access to vital parts was usually difficult, so that replacements of worn or broken parts required an excessive amount of time and frequently caused unreasonable delays to gangs.

In many instances these early machines were designed by persons who had only a hazy knowledge of railway requirements. In others, parts were not properly proportioned; and breakage was common. As a consequence, some machines were wholly unsuited for the purpose for which they were designed and soon passed from the scene. Others were redesigned, either in whole or in part, the better to suit them for the work they were to perform, to strengthen weak parts or to give them a wider range of usefulness.

An experience was gained in the field and in the shop, opportunities were discovered to improve designs to increase efficiency, to increase ease and flexibility of operation, to obtain greater precision of parts and to insure greater dependability. This form of progress has been continuous from the beginning and is being carried on at an accelerated rate today, for the railways are purchasing more and more equipment; and maintenance officers are demanding better performance from their machines.

In the beginning, many of the improvements were radical; and some were fundamental in character. Today the design of power machines and power tools is much more stabilized, and in developing improvements there is little departure from the fundamental designs that have been shown by experience to be adapted for the various classes of work for which the machines were intended. Yet when one studies the various machines and tools that are available today, comparing them with the designs of five years ago, or even a year ago, an astonishing amount of effort and activity directed toward the improvement of this equipment becomes apparent. Furthermore, this activity is not confined to any type of machine or to any manufacturer but is general and all inclusive.

Largely because of ill-conceived or inadequate designs, many of the early power machines became obsolete almost as soon as they were brought out, since they were followed almost immediately by better designs. Today, obsolescence is a factor of equal importance in the use of work equipment, despite the greater stability of design that characterizes the industry.

Developments in Progress

This review has been given to show that the design and construction of power machines and power tools are not static but are constantly progressing along the road to further improvement, and that although many of the problems that confronted early designers of this equipment have been met and solved, others are presenting themselves and are demanding solution. In this respect, today is no different from yesterday, except in the character of the problems that arise.

The committee was requested to study and report on the improvements that have been made in the various types of work equipment during the last five years, and to report separately those that were made during the last year. For several reasons it was impractical to do this in detail for, while a few clear-cut examples of important improvements made during the last year were found, most of the changes appeared to be minor in character and involved no change in principle or in basic design, although many of them have been of decided benefit in the operation of the machines. Again, it should be borne in mind that many of the machines under discussion are highly competitive, and in some instances where a manufacturer makes a desirable improvement, a

similar or comparable improvement is made by his competitors one or two years later. If three or a dozen manufacturers follow the same trend, but carry it through several years, it is impossible to say that the improvement in a specific type of machine was made during a particular year. This difficulty is also complicated by the fact that in making important changes in design, some manufacturers allow the existing models to remain unchanged and present the improved design as a new model. For these and other reasons trends rather than details will be discussed.

In making such a study, one cannot fail to be impressed by the larger range of off-track designs that are available compared with five years ago, a development that is being stimulated by the higher train speeds of today as well as by the demands of train-service employees for the right to participate in the operation of on-track units. Probably the next most striking development is the extension of anti-friction bearings to all classes and types of work equipment. This is only one indication, however, of a larger movement having as its objective greater ease and flexibility of operation, lower power consumption and decreased maintenance.

Larger Power Units

It was stated that many of the early machines were under-powered. This defect has continued to afflict many types and makes of power machines throughout the quarter century of development of work equipment. Today this is being corrected by the installation of larger engines or by increasing the number of cylinders from four to six, with the further purpose of eliminating the undesirable vibration that is characteristic of the four-cylinder engine. In this connection, it is also noted that there is a distinct movement toward units of larger capacity, particularly in the case of cranes and some of the earth moving equipment, such as draglines, carryalls and crawler-mounted dump wagons.

It is also noted that aside from increasing the horsepower of engines and the number of cylinders, particularly on the larger units, there is a marked drift toward increasing engine speeds, and to redesign engines with the purpose of reducing fuel consumption without reducing the effectiveness of the unit. Within the last two years there has also been developing a tendency to substitute Diesel engines for gasoline engines on the larger units, such as cranes, power shovels, draglines, etc., and to replace steam-driven equipment with units powered with either Diesel or gasoline engines. This movement has not yet gathered much momentum; and the rate at which Diesel power will be accepted by the railways for use on work equipment is not yet apparent, although one road has already decided to purchase in the future only equipment, of the larger sizes, that is powered by Diesel engines. While it is generally agreed that the Diesel engine is superior to the gasoline engine for many types of service, and that it is more economical, the facilities for delivering fuel oil to units that must be moved frequently, sometimes for considerable distances, have not yet been developed; and this may retard somewhat the introduction of this form of power for use on work equipment.

Simpler Designs

In addition to the greater economy of operation which every manufacturer is striving to attain, there is a general movement away from the complicated designs which have been so much in evidence from the beginning. This trend is seen in easier access to working parts, a feature that is being stressed by almost all manufacturers. Another indication of this trend is that welded construction is replacing rivets in numerous instances. Again, some manufacturers are building their machines so that propulsion is completely independent of the operating mechanism. A recent feature of considerable importance is the application of hydraulic and pneumatic control of clutches on the

larger units, thus reducing the reciprocating parts of the clutch, and making it simpler, easier and less fatiguing for the operator to manipulate the levers. Another improvement that is being featured by certain manufacturers is the increased window space in cranes and power shovels, to give operators a wider range of vision, both laterally and forward.

One cannot help being impressed by the almost universal efforts that are being made to simplify and reduce maintenance. Parts are being strengthened, not only by improved design, but through the use of better materials with the purpose of prolonging their life, as well as to assure greater dependability of operation by reducing breakage and wear. Some manufacturers are using splined instead of keyed shafts with the same purpose in mind, and others are enclosing transmission gears and immersing them in oil to decrease wear and increase dependability. Again, others are resorting to synthetic rubber to cushion vibration because of its superiority to the natural product for this service.

Another striking feature of recent designs that can be traced through almost every type and class of maintenance of way work equipment, but is particularly evident in the units used by the smaller gangs, is the effort that is being made to reduce weight. While this movement has already gained considerable momentum, not a few maintenance officers assert that there must be a much further development along this line before the machines will be of maximum service.

That there has been a marked development in all classes and types of power machines and power tools employed in maintenance during the last five years, and that in not a few cases these developments have exceeded those of the previous two decades, will be apparent to any one who cares to study the subject and compare the machines of today with those of the earlier period. The importance which manufacturers attach to keeping abreast of the changing needs of the railways and the more severe demands upon their equipment, is illustrated by the fact that of six machines produced by one manufacturer, five were redesigned in preparation for his 1941 production; and several minor changes were made in the sixth.

The all-purpose machines of the earlier period are no longer in evidence, yet those that remain are more flexible than their predecessors; and many of them are well-fitted to perform classes of work other than that for which they were designed. Safety has been given an important place in recent designs. The precision with which parts are made and assembled and the better materials that are being employed have all tended not only to extend the life of the machines but to make their operation more dependable and thus reduce time lost by gangs through breakage of parts. An example of the trend toward greater efficiency is found in the two-stage air compressor which has almost universally replaced the older straight-line design. Another but somewhat different illustration is the adoption of the variable-speed engine on certain types of power machines to increase the flexibility of operation.

Important Needs Still Unfilled

The use of work equipment has expanded greatly during the last five years, in fact, at a faster rate than at any time during the quarter century it has been under development. As a corollary to this wider use, machines are available today to perform work that was wholly a hand operation as recent as ten years ago. Yet despite this widening use and the development of new machines to meet a constantly broadening demand, there are still a number of important unfilled needs, for which no power machines are yet available.

One of the most widely discussed and most insistent of these requirements is a one-man inspection car weighing not more than 400 lb., and preferably not more than 375 lb. Many maintenance officers believe that a practical one-man motor car of this weight can be built which will have all of the necessary parts and which will serve a greatly needed purpose. The committee's attention has been called quite forcibly to the fact that no such car is being built at present, since none of those available today weighs less than approximately 525 lb. when ready to run, and ranges as high as 644 lb. The committee's attention has also been directed to the fact that catalog weights do not represent actual weights of the cars, but range from 60 to 90 lb. less than the actual light weights, and from 95 to 125 lb. under the weights of the cars as serviced for operation. It has been suggested that the manufacturer stencil on the car the actual weight when filled with gasoline and water ready for operation.

Another unfilled need is for an electrically-operated impact wrench. The pneumatic impact wrench, although a recent development, is meeting an important need and has made a place for itself, particularly in bridge work. However, many bridge gangs are equipped with only electric generators and electric tools; and an electric impact wrench would be a welcome addition to their equipment.

As previously mentioned, while there has been a definite effort on the part of some manufacturers to reduce the weight of their machines and tools, maintenance officers are of the opinion that this movement has not gone far enough and are insisting that it must be continued to make the equipment of greatest value to them. In this connection, the use of ac. tools using higher frequencies than 60 cycles has indicated that there is a definite advantage in the reduction of weight and size of tools employing 180 cycles or higher frequencies. Welding units having an output of 200 amp., operating at as much as 900 cycles are in use. These units, complete with power plant are available at weights of as little as 800 lb. and with dimensions that permit them to be operated between tracks of multiple-track lines. This indicates that there are possibilities in this form of equipment. Furthermore, power plants necessary to drive high-cycle tools are, by virtue of their inherent construction, smaller and lighter than those of the same output operating at lower frequencies.

Still another unfilled need is that of a simple, effective and practical signal that will warn track and bridge gangs of the approach of trains when working at points where the view is obstructed. The desirability of such equipment is obvious; but as yet no simple, practical system has been developed.

A number of self-contained power tools, notably the unit tie tamper, have been developed, which have filled an extended need for small gangs because they do away with cumbersome power plants, but which are equally adapted for use by large gangs. There is today a keenly-felt need for a self-contained spike driver which can be used to equal advantage by the section forces and gangs engaged in laying rail and ballasting.

Several machines are now available for cleaning the shoulder ballast, and there are also devices for removing the crib ballast to the shoulder where it can be reached by the cleaners now available. There is a real need for equipment that will in one operation clean and replace the crib ballast either independently of that on the shoulder or in connection with that operation.

There is a growing need for a high-speed portable rail saw that can be used in the field to cut rails without removing them from the track, as well as before they are laid in the track. What is wanted is a self-contained machine of easy portability that will cold cut a 112 or 131-lb. rail in approximately one minute or less.

While lighter-weight track tools are not a part of the committee's assignment, they are a corollary to it and will, therefore, be mentioned. The movement toward lighter section cars is now being accompanied by a demand for lighter track tools. The average section foreman is unable to understand why he should be required to carry a complement of tools that weighs as much or more than his car. It has been suggested that track jacks of ample capacity for all ordinary requirements could be made considerably lighter, perhaps not over 20 lb., and that the weight of the clawbar and the lining bar can be reduced somewhat without reducing their effectiveness.

There are definite trends in the design of power machines and tools intended for maintenance of way purposes which are leading to desired improvements in numerous units, looking toward greater efficiency, easier and more flexible operation, lower fuel consumption, lighter weight, greater portability, simpler design, greater dependability and longer life of parts. While this trend had its inception more than five years ago, it has been considerably accelerated during this period, so that many machines that were the last word in design no longer than five years ago are outmoded and obsolete today.

Report on Assignment 6

Color of Roadway Machines

N. W. Hutchison (chairman, subcommittee), C. M. Angel, L. B. Holt, C. H. R. Howe, C. E. Morgan, P. G. Petri, J. L. Starkie, Roy Wade, F. F. Zavatkay.

The following is submitted as a final report presented as information with the exception of recommendations for adoption and publication in the Manual.

A thorough report under the heading of "Standard Colors for Work Equipment and Motor Cars" was presented to the Association by this committee in 1931, the report having been published on pages 470–472 of Volume 32 of the Proceedings with the following conclusions:

"The most suitable colors for use on motor cars and work equipment are as follows:

For motor cars—Yellow (medium chrome)
For light work equipment—Yellow (medium chrome)
For heavy work equipment—Black."

Subsequent investigation and observation indicates that the color recommended previously is not being used generally. However, it is believed that this lack of use is the result of conflicting opinion arising from the absence of specific terminology rather than dissatisfaction with the recommended color. Observation of color charts issued by leading paint manufacturers illustrates the fact that there is no general agreement as to the exact shade of the color which is designated as medium chrome yellow.

In view of this apparent conflict of opinion, it is the purpose of your committee in this report to so revise the conclusions adopted in the previous assignment that a definite color and definite shade will be established as standard and that information will be furnished indicating exactly how this standard shade may be obtained.

Disregarding quality and price as factors, the prime requisites in the selection of a paint color for use on roadway machines are maximum visibility under all conditions

of weather and favorable color retention. Unfortunately, there are many conflicting opinions relative to the color that offers maximum visibility, primarily due to the fact that visibility of any color is greatly dependent upon the colors forming the background and is considerably enhanced when in close proximity to a decidedly contrasting color.

It has been recognized generally that yellow and orange offer high visibility under all weather conditions and yield good contrast against most backgrounds, and that contrast colors, used together, offer greater visibility than solid colors. A comparative test conducted by the Material Division of the Air Corps, United States War Department in 1935, to determine whether the color scheme of yellow and black or international orange and black is preferable under all conditions of weather, for the painting of obstacles, resulted in the following conclusions:

1. The yellow and black combination is visible from a greater distance than the orange and black.
2. For dull or normal days the yellow and black combination is superior to the orange and black.
3. The orange and black combination is best at close range and on very bright days.
4. Contrast colors are desired in preference to a solid color.

Subsequent to this test it was found that in some localities the use of yellow and black did not afford proper contrast with the background; and consequently, the use of orange and black was approved as an alternate method of painting. At the present time, combinations using yellow and black or orange and black are used by the Air Corps, the one selected being that which will afford the most contrast with the background.

The Public Roads Administration has standardized on yellow for the painting of highway signs; federal and state highway equipment is painted yellow; and your committee in its previous report recommended yellow for motor cars and light work equipment. Therefore, it is the opinion of the present committee that yellow should remain as the chosen color for the purpose intended.

Due to the wide variety of yellow shades and the existing confusion relative to the nomenclature used to describe these various shades, simply to designate the selected color as yellow is unconvincing and valueless. It is important to choose a shade for which there is a definite specification having universal application.

United States Government Colors

Various departments of the United States Government have standardized on a color known as "Yellow No. 4" which is the standard medium chrome yellow and for which there are specifications numbered TT–P–53, designated as "Federal Specification for Paint; Outside, Ready Mixed, Medium Chrome Yellow".

Another color, commonly known as "Federal Yellow", which is slightly lighter than the government standard "Yellow No. 4" has been adopted by the Public Roads Administration, this bureau designating it "Highway Yellow". It is used for marking highway signs and was selected because of its conspicuous visibility against most backgrounds and because it yields good contrast against black symbols or letters.

It is the opinion of your committee that this color, generally known as "Federal Yellow" should be adopted as the standard color with which roadway machines should be painted. This color approximates plate number 10–L–3 in the Maerz and Paul "Dictionary of Color."

There is no Federal Paint Specification covering Federal Yellow paint. However, when so desired it can be purchased under Federal Specification number TT–P–53 provided the color specification is met, the only change being that, in the composition of the pigment, the total chromium shall be not less than 38 percent lead chromate, instead of 54 percent lead chromate.

As a matter of information, the following pigment mixture has been found to match Federal Yellow:

40 percent C. P. Lemon chrome yellow
20 percent C. P. Medium chrome yellow
20 percent Zinc oxide
20 percent Barytes.

Conclusions

It is the opinion of your committee that the color commonly known as "Federal Yellow" is the most suitable for painting roadway machines, including motor cars and light work equipment.

Recommendations

It is recommended that the color "Federal Yellow" be adopted as the standard color for roadway machines and that this recommendation, along with a color plate illustrating the exact color, be submitted in 1943 under the subject, "Revision of Manual."

Report on Assignment 7

Push Cars and Trailer Cars

C. H. Ordas (chairman, subcommittee), G. J. Ermentrout, J. G. Hartley, R. K. Johnson, C. R. Knowles, Jack Largent, F. H. McKenney, E. H. Mills, R. A. Morrison, P. G. Petri.

The report is presented as information with the recommendation that the subject be discontinued.

Ever since the track motor car was first furnished to the maintenance of way forces of the railways to replace the pump or hand car, the manufacturers of motor cars have gradually improved the power car so it could pull heavier loads at greater speeds for the movement of materials and men. Because of this, it has been necessary also to redesign and improve the push and trailer cars, for the safer operation of the equipment, in the sometimes limited time between trains.

In the days of the hand car, the push cars were fabricated in the maintenance shops of the railways, using much of the material salvaged from the old hand cars. Many of the railways are now using salvaged parts from the present day motor cars for this same purpose; but most of the manufacturers of motor cars are also offering for sale both push cars and trailer cars, which many of the railways are purchasing. Regardless of how this equipment is obtained, it should be fabricated of the best of materials to avoid failures.

Many types and capacities of both push cars and trailer cars have been constructed and used. Special types have been made for the movement of off-track machines, including some of the underslung type, in which the top or deck has been

Fig. 1.—A Light Push Car, Type No. 1, with Welded Steel Frame and Wood Floor. An Alternate Design Has a Wood Frame and Wood Center Wheels.

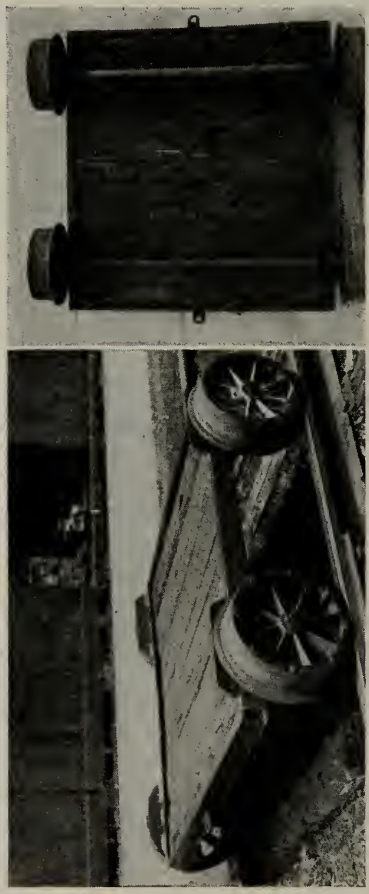


Fig. 2.—A Light, Sturdy Push Car, Type No. 2, for a Section or Small Gang.

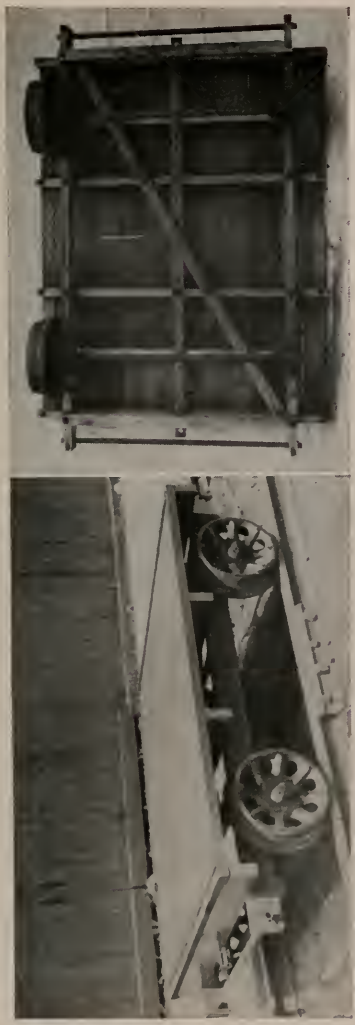


Fig. 3.—A Push Car, Type No. 3, for Bridge and Building or Extra Gang Use.

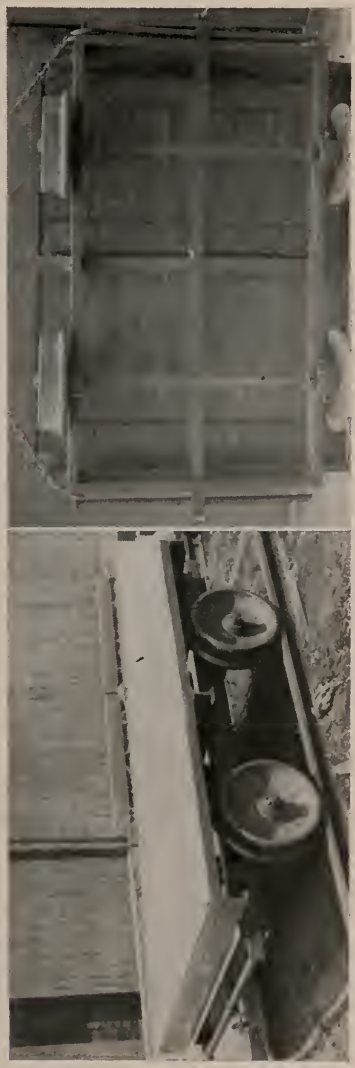


Fig. 4.—A Heavy Duty Push Car, Type No. 4, for Distributing Crossties, Rails, Bridge Timbers or Other Heavy Material.

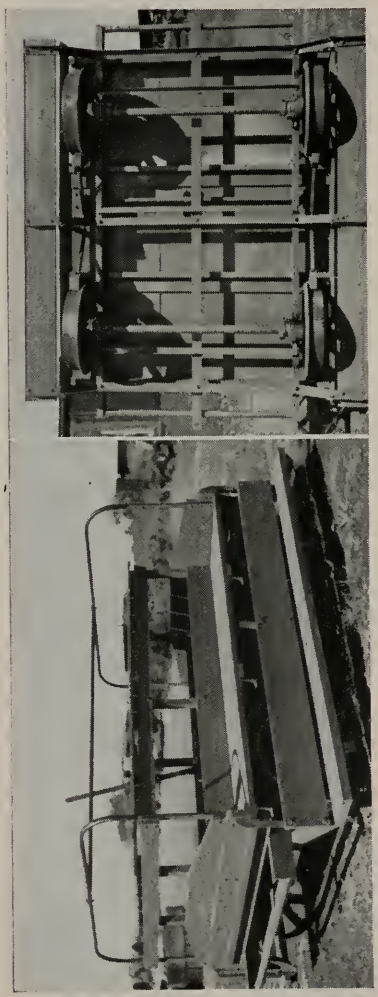


Fig. 5.—A Trailer Car for Handling Men.

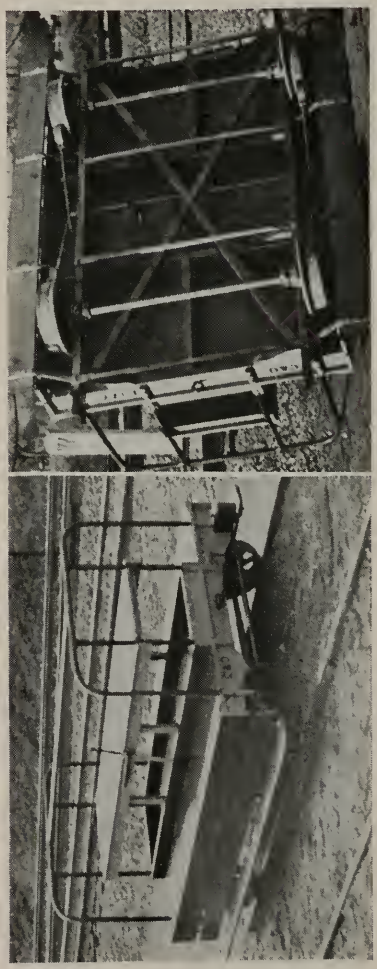


Fig. 6.—An Alternate Type of Trailer.

Fig. 7.—An Underslung Type of Car. The Design, Weight and Capacity Will Vary Depending on the Character of the Load to be Handled.

placed lower than the axles, to facilitate the loading of equipment by the use of ramps or aprons at the side of the push car.

Some railways have also designed and built special sturdy chassis with low track wheels and telescoped pipes or sections of rail, to facilitate the removal of large machines from the chassis to various types of cribs at the side of the track to clear trains.

Your committee, after reviewing the replies to a questionnaire addressed to representatives of member railways and discussions of approved practices, offers the pictures and conclusions presented here.

The recent introduction of the demountable wheel permits the ready removal and replacement of the worn or defective plate alone. Some railroads are using what is known as the welded type of wheel with success, but this type involves the removal of the hub when the wheel needs replacing.

The differential axle is now also coming into use on motor, push and trailer cars, because it obviates the use of loose wheel bushings and permits the desirable practice of insulating every wheel.

The use of alloy steel axles is not necessary if carbon steel axles of adequate size and specifications are used; such as SAE 1035 or SEA 1045. Those who use alloy steels, use them on motor cars only, and then often only on the drive axle.

It is recommended that decks of push cars be wide enough to cover the wheels, and under these conditions the 16-in. diameter wheel is preferred.

Dump box sills with steel straps on the top face, also steel straps on the deck top, are desirable if rough, heavy materials are to be transported on the cars.

All exposed wood corners on floors and footboards which are liable to be bruised, slivered or checked, should be protected by angle irons.

The capacity of each car should be shown on each car so those using it may be governed accordingly. Figs. 2, 3 and 5 illustrate cars in which optional use may be made of 16-in. wheels of $\frac{5}{16}$-in. plate. The weights of the cars may vary, depending on the weights of the material used in their construction.

Conclusions

Some trailers are of the convertible type, from which the seat, the tool box under it, the full-width safety rail at each end and the footboards may be easily removed, so the car may be used as a push car. The removal of the footboards is also desirable to facilitate the loading of the car into box cars with narrow doors when flat cars are not available.

There is no uniformity of practice as to the location of the brake lever on trailers; where trailers are of the convertible type, it is obvious the side application is best.

It is desirable that all the wheels, axles and bearings on the equipment in any one gang be of the same size and type and interchangeable, so only a minimum number of replacement parts need be carried.

Some maintenance officers prefer 16-in. wheels on push cars and trailers to get a low center of gravity; however, others prefer the 20-in. wheels as they are much easier to push in soft ballast and lift over rails.

Cast wheels are approved only on push cars of five-ton capacity or larger. Push cars of smaller capacity should be provided with plate wheels of the requisite plate thickness for the capacity of the car.

Principal Features of Types of Cars Shown in the Illustrations

Type No.	*Car Type*	*Capacity Tons*	*Weight Lb.*	*Deck Wide in.*	*Deck Long in.*	*Wheels Dia. in.*	*Wheels Plate in.*	*Axle Dia. in.*	*Sills*
1	Push	0.5	365	52	55	14	3/16	1¼	Steel
2	Push	1.5	555	52	72	20	¼	1½	Wood
3	Push	3.0	730	66	82	16	5/16	1 11/16	Wood
4	Push	5.0	1600	68	84	18	Cast	2	Steel
5	Trailer	3.0	1100	68	84	20	5/16	2	Steel

All cars are equipped with roller bearings, with inner races placed back to back in the housings, and effective thrust collars.

Report on Assignment 14

Power and Bonding Drills

E. H. Mills (chairman, subcommittee), R. M. Baldock, G. T. Donahue, J. G. Hartley, H. C. Hayes, L. B. Holt, R. K. Johnson, W. G. Kemmerer, C. E. Morgan.

This report is presented as information with the recommendation that the subject be discontinued.

Under present day conditions, the manual drilling of holes in rail for track fastenings, bonding or other purposes is too slow, especially when other track work is being done by mechanized equipment. Along with other devices built to do better work in less time, power track drills have been developed and are available in several forms to perform this operation better and faster than it can be done by hand. It is the purpose of this report to discuss the design and use of these machines.

Power drills may be driven by gasoline, electric or pneumatic motors and the choice of the most suitable involves a consideration of many factors.

Gasoline motor driven drills have the great advantage of being self-contained and not dependent on any outside source of power. They are easily transported and can be put in service quickly at almost any location. By means of a variable speed governor or hand throttle, drill spindle speeds may be controlled to some extent. Ordinary labor may be used for their operation, and repairs and servicing offer little difficulty. Generally, they require more space and are heavier than electric or pneumatic machines. In some locations their use is prevented by fire safety considerations or the danger of carbon monoxide poisoning from the exhaust. The possibility of interruptions due to breakdown is greater than with electric or pneumatic source of power.

Has Numerous Advantages

The electric driven drill has numerous advantages which makes its use desirable under certain conditions. It is relatively light and occupies a small space. The speed is constant, and starting and stopping is accomplished by turning a switch. The possibility of breakdown interruption is not great. Changing weather conditions have little effect on its operation. Where a convenient current service is available, it offers a minimum of delay and a maximum of performance, as the electric motor is reliable, clean, silent and mechanically efficient. The electric drive, however, has some serious drawbacks. Lack of a permanent source of power and differences in current characteristics will restrict its portability unless an attending gasoline engine generating set is used, in which case it has but few advantages over the direct drive gasoline machine. In case of failure, repairs are not as quickly accomplished as with other power. There is always the possibility of electric shock to the operator if high voltage is used or dampness is present at the working location. Cables and connections have to be maintained and rapid changes of location are not readily made.

Pneumatic power is reliable, clean, safe and easily controlled. Weather conditions, except possibly extreme cold, have little or no effect on operation. Starting and speed control are by a simple hand throttle. Small space is required and the air motor needs but little in the matter of servicing and repairs. It is light and can be easily connected by the ordinary workman. Its use is seldom attended with danger. Where there is a permanent supply of compressed air, this source of power is most satisfactory. Away from a permanent source of air a portable compressor must be used, but this is a heavy and mechanically inefficient source of power. For each horsepower produced by the air motor, four or more horsepower must be provided for compressor power. Suitable air lines, hose and connections must also be provided and serviced. Unless there is a large volume of work to be done in a relatively small area, compressed air will not be satisfactory as a source of power.

Manufacturers of track machinery now supply portable, single-spindle, self contained machines, fitted with convenient lifting handles, driven by air cooled gasoline motors and capable of drilling holes up to 1½ in. diameter.

Gas Engine Driven Drills

Fig. 1 shows such a machine weighing 350 lbs., the main frame of which is a malleable casting mounted on two single deeply flanged wheels with weight distribution and handles so arranged that the unit may be tilted against the wheel flanges and rolled along the rail. Each of the flanged wheels has an individual eccentric mounting operated by a lever and locked with wing nuts, which provide a quick vertical adjustment through 1¾ in. for the drill. A lever-operated hook over the rail provides the hold against the thrust of the drill. This hook has two positions, pin retained, one for holes to be drilled where joint bars are in place and one for bare rail. Two short arms, closely spaced on either side of the drill, adjustable for length and actuated by a ratchet-retained hand lever, serve to clamp the machine square to the rail against the hook over the rail. A ratchet-lever-operated, vertically-hinged shoe parallel with the rail and long enough to span the crib space, provides a levelling adjustment on the end away from the drill.

The motor is started by rope pull and has a hand set variable speed governor. It is located directly above the drill spindle to which it is coupled without clutch through vertical shafting and bevel speed reduction gears completely enclosed and running in oil.

The drill spindle speed is 75 to 90 r.p.m. depending on governor setting. Total end movement of spindle is 6-in. and is actuated by a hand wheel for quick adjustment up

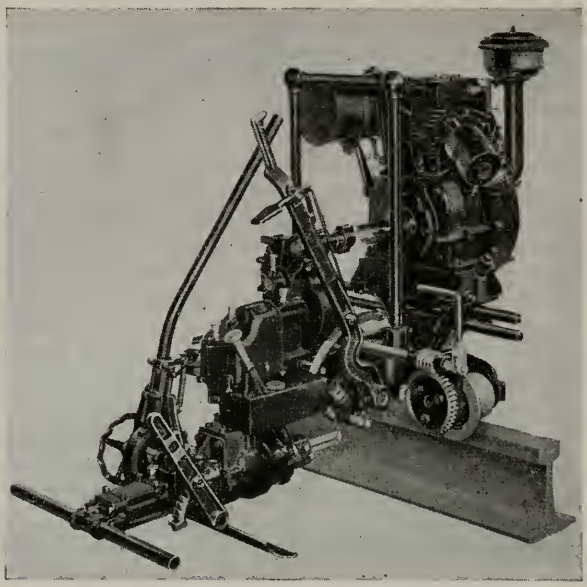


Fig. 1.—Gasoline Engine Driven Rail Drill.

to the work. The drill is fed into the work by a long hand lever through a ratchet working on a pinion and rack against a conventional thrust bearing on the spindle. A built-in oil reservoir and manually-operated plunger pump provides drill lubrication. The spindle can be fitted with chuck or socket for any type of drill. Holes cannot be drilled nearer than 12 in. to rail end unless the adjoining rail is in place. A clear space 24 in. away from rail on one side and 1¾ in. on opposite side is required for clearance.

This drill can be quickly adjusted to the work and moved from one position to another. A 1⅛-in. diameter hole may be drilled in 60 sec. It is claimed the carefully proportioned manually-operated drill feed has advantages over automatic feed in that drilling is just as rapid, and fewer drills are burned or broken. It can be operated and shifted along the rail by one man, but two men are required for lifting into clear. The operator stands while the drill is working.

There is another machine, weighing 290 lb., which is of different design but of comparable efficiency. Its main and sub-frame are fabricated by welding steel plates, rolled sections and tubing. This is supported when being moved on two retractable double flanged wheels bearing on the rail to be drilled. A light tube, which can be placed on either side of the machine, depending on which side of the rail the drill is to work, extends to the opposite rail where it has a roller on its outboard end to stabilize the machine when it is being pushed from one location to another. When drilling, the flanged wheels are retracted; and the machine then rests on two vertically hinged levers which bear on tbe rail and are actuated by a right and left hand screw driven by a ratchet handle to provide vertical adjustment for the drill. An adjustable rail hook with 14 in. of travel mounted on the main frame provides the reaction for the thrust of the drill. The drill is brought into contact with the rail by means of a quick-acting, crank-driven feed screw moving the motor and drilling mechanism that are mounted as a unit

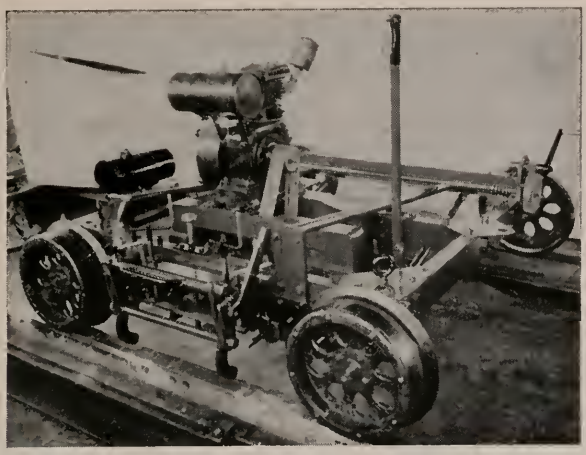


Fig. 2.—Gasoline Engine Driven Multiple-Spindle Rail Drill.

on slides which are part of the main frame. A ratchet handle on a squared section of the feed screw is used to force the bit when drilling.

The three-horsepower motor is started by hand crank, has a variable speed governor and is connected through a hand operated friction clutch. Speed reduction is by spur gearing, mounted on ball bearings, enclosed and running in oil. Final drive to the drill spindle is by an enclosed roller chain. The maximum spindle speed is 130 r.p.m. A special drive-out chuck is provided for double-beaded, flat, high-speed steel drill bits. This has a simple adjustment for various lengths of drills, and no tool other than a hammer is needed to make a change. The drill thrust is taken by a special ball bearing. The motor, clutch, gear reduction, chain drive and drill spindle form a unit which, as mentioned before, slides on the main frame when the drill is feeding into the work. A space approximately 18 in. away from the rail is needed for clearance. The operator stands while drilling.

This drill may be quickly adjusted and moved from one location to another along the rail by one man. Two men are required to lift it into clear.

A recent development shown in Fig. 2, is a portable gang drill, with three spindles and the ability to drill one, two or three holes at one time. This was designed primarily for use with programs of rail end cropping, but can also be used for drilling on other work.

This drill is mounted on a fabricated steel chassis supported on four small flanged wheels and eccentric axles in such a manner that by means of hand-crank-driven worm gears, the whole unit may be raised or lowered to provide vertical adjustment of the drills and to clear the rail head when moving. The drills operate from the inside of the rail and are driven by a five horsepower gasoline engine. The first speed reduction is by multiple "V" belt to a countershaft which actuates the main shaft of the drilling head through a gear box. This main shaft drives the drill spindles through helical gears. An adjustment permits the spacing of the drill spindles as desired, both with respect to each other and relative to the rail end. For feed purposes, both the power and the drilling head are mounted on a carriage which moves transversely relative to the track on two

guide shaft slides. The feed thrust is provided by a hand-operated lever through a rack and pinion arrangement. A pair of curved arms which can be adjusted to bear on the outside of the rail helps to resist the lateral thrust imposed during the drilling operation. These arms, which are hinged to raise them into clear, also act as the support for a screen guard for stopping pieces of metal that may be dislodged when the drill points break through. The drill spindle chucks take flat, double-beaded, high-speed drill bits; and it takes approximately two minutes to drill three holes simultaneously. A lubrication device feeds oil to each drill.

Electric Drills

For power bonding and other rail drilling there is available a specially designed electric drive single spindle machine weighing approximately 200 lb. and capable of drilling holes up to 1½ in. in diameter. This is shown in Fig. 3. The main frame consists of two parallel steel tubes spaced 11½ in. center to center and long enough to span

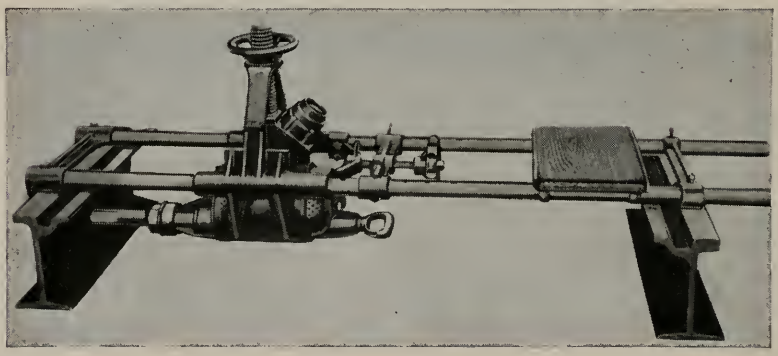


Fig. 3.—Electric Drive Rail Drill.

standard gage track. Hand grips at the ends of the tubes provide a convenient means of carrying. The ends of the tubes are held by cast spreaders, the one at the drill end having lugs extending downward outside the ball of the rail to take the thrust of the drill.

The electric motor is one horsepower and is available in various current characteristics. The gear reduction train is mounted on the end of the motor frame and is completely enclosed, running in oil. The drill spindle is on the lower side and requires 2½ in. for clearance. A hand switch is provided on top of the motor for starting and stopping. In appearance this part of the unit resembles a conventional electric drill.

The motor with its gear reduction and drill spindle is mounted on a casting which is free to slide on the parallel tubes of the main frame. This casting carries a vertical slide with a range of 6 in., adjustable by means of screw and hand wheels to provide the necessary vertical drill adjustment. The drill feed screw is attached to a movable spreader casting, sliding on the tubes of the main frame and held stationary as needed by quickly removable stop pins through holes in the tubes spaced about three inches apart. The feed screw has a range of 3½ in. and is provided with a hand wheel for quick adjusting and a squared end for a ratchet wrench for hand feed. There is no provision for automatic feed.

The drill spindle has a Morse No. 3 taper shank socket, and provision can be made for any type of drill. The loaded speed is approximately 100 r.p.m. A space 28½ in. from gage side of rail is required. Holes cannot be drilled nearer than 6 in. to the rail end without bolting on another rail. A board seat is placed across the two pipe members of the frame on the end away from the drill, and the operator sits while working the feed screw.

Numerous home made devices have been produced to make use of power driven nut runners for rail drilling. These appear on almost every railroad where nut runners are in use and regular power rail drills are not available. One of these, shown in Fig. 4, is a conventional hand drill altered in such a manner that the hand drive is replaced by an adaptor to which the nut chuck of the nut runner furnishes the power.

There is at least one regularly manufactured device for using a nut runner to furnish the power for drilling. This, shown in Fig. 5, consists of a rail hook attached to a welded frame carrying a feed screw actuated by a hand crank on one end for quick adjustment, a ratchet handle on the other end of the screw for feeding the drill, two wing nut screws bearing on the rail for vertical adjustment and a sliding head with drill spindle, thrust bearing and knock out chuck. An adaptor on the end of the drill spindle takes the chuck of a nut runner.

Generally these devices are effective but slow. They have the advantage of requiring small investment, they make use of a source of power which happens to be available and idle and they provide a power drill where otherwise the work would have to be done by hand. Their use should be limited by these considerations.

Wheelbarrow Mountings

Another power adaptation to a hand drill is shown in Fig. 6. This is a flexible shaft-driven drill attached to take the place of hand power on a commonly used make of rail drill. The source of power is a wheelbarrow-mounted air cooled gasoline engine with "V" belt drive to the flexible shaft. The drill head furnishes the necessary speed reduction. While not as portable as other devices, it is serviceable and makes use of an available power source for work that would otherwise have to be done by hand.

One manufacturer offers a simple rail bolt hole drill weighing 104 lb., to use flat beaded drill bits up to 1½ in. diameter and driven by a portable gasoline motor through a flexible shaft. This, shown in Fig. 7, consists of an enclosed, ball-bearing-mounted, worm gear speed reduction unit driving the drill spindle and arranged to slide on a frame of parallel rods attached to the usual rail hook at one end and an adjustable levelling shoe resting on the crib at the opposite end. The rail hook has an adjustment for drilling with or without the joint bars in place, also a hand screw vertical adjustment for the drill location. The drill feed is effected by a long ratchet hand lever through a pinion and rack. The operator stands with one foot on the levelling shoe while drilling. Holes may be drilled within 3 in. of rail end. A space of 30 in. is required away from the rail on the side being drilled for clearance. This device is moved between drilling locations on the portable wheelbarrow type mounting of the motor. The flexible shaft is attached to the drill by a bayonet type connection and can be quickly disconnected to permit the use of various types of heads for other work.

Track Bolt Drills

Figs. 8 and 9 illustrate pneumatic track bolt drills as manufactured in several different forms. These are always conventional drills adapted to this special use. The most common form consists of a rectangular frame built up of two parallel rods, with rack teeth cut on the under side, held in spreader castings at each end. The spreader at

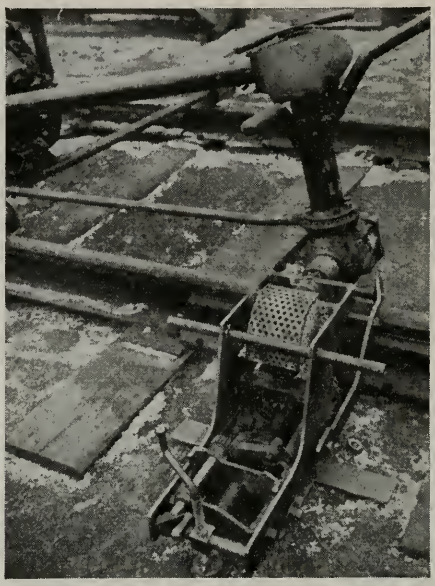


Fig. 4.—Nut-Runner Driven Rail Drill.

Fig. 5.—Nut Runner Driven Rail Drill.

Fig. 6.—Flexible Shaft Driven Rail Drill.

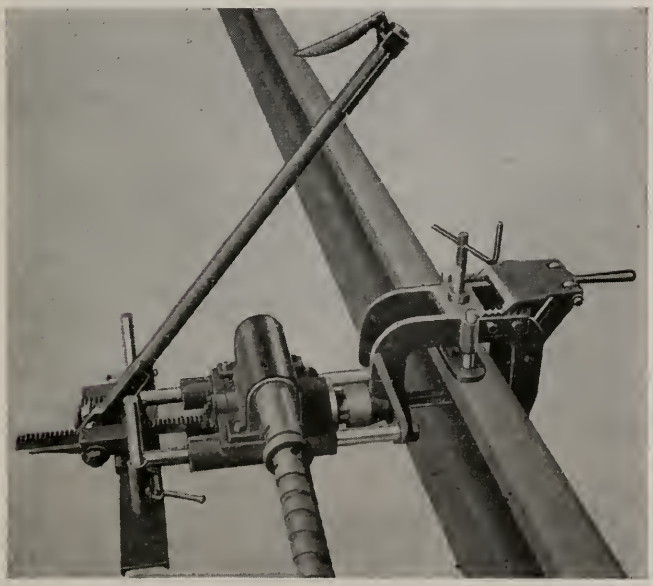


Fig. 7.—Flexible Shaft Driven Rail Drill.

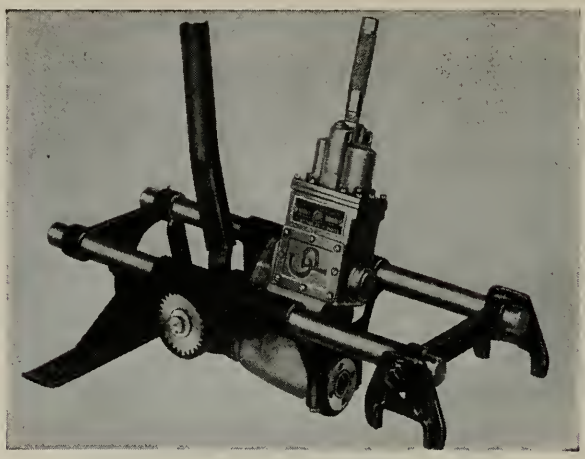


Fig. 8.—Pneumatic Rail and Bonding Drill.

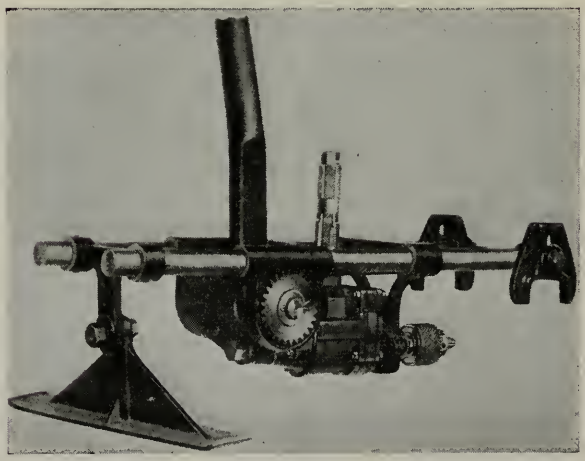


Fig. 9.—Pneumatic Rail and Bonding Drill.

the rail end has bolt-retained adjustable slides which hook over the rail head to provide reaction for the thrust and the vertical adjustment necessary for locating the hole. The spreader at the opposite end carries a vertically adjustable, bolt-retained shoe which rests on the crib. A regular pneumatic corner drill with the feed screw removed is mounted on a casting which slides on the parallel side members. This carries a gear, meshing with the rack teeth and actuated by a long ratchet handle to provide the drill feed. This handle is convenient to the operator who stands with one foot on the crib shoe to hold the end down when drilling. A hole for a track bolt may be drilled in less than 60 sec. The whole unit has to be carried when changing location. A special chuck has to be provided if flat beaded drill bits are used.

Fig. 10.—Gasoline Engine Driven Bonding Drill.

Similar pneumatic drills are available using smaller, higher speed motors for bond hole drilling.

One self contained, gasoline engine driven drill weighing approximately 200 lb., designed for the specific purpose of rapid drilling for signal bonds is available. This, shown in Fig. 10, has a one-horsepower single cylinder, air cooled motor with a pull starter and variable speed governor. The power take off and speed reduction are effected by a double "V" belt with the final drive to the single drill spindle through enclosed spur gears running in grease. There is no clutch.

The frame is of cast steel and is supported on two single flanged rollers bearing on the rail to be drilled. These rollers are on hinged mountings to provide quick vertical adjustment for the drill through a range of several inches by means of worm and segment gears worked by a ratchet handle on the worm shaft. Convenient handles for lifting and moving are provided. The weight is balanced so the machine may be tilted against the deep single flanges of the rollers and moved easily and quickly between drilling locations. All the other necessary rail hook, clamping, levelling, drilling depth and other adjustments can be made rapidly without the aid of tools. The drill feed is by a ratchet hand lever and a drill oiling device is provided. The operator stands with his left foot on a lever which clamps the machine to the rail while drilling. Holes cannot be drilled under 12 in. from the rail end unless the adjoining rail is in place. Holes may be drilled through the web or to a depth limit in the head. A space approximately 24 in. from the rail on the side being drilled is required for clearance.

Except for the small diameter holes for bonding, most of the drilling consists of large diameter holes in the thin vertical section. Feed pressures are apt to be high; and with the hard service required of any track tool, breakage of conventional twist drills

in power drilling machines is unusually high. To reduce the cost of drill bits and delays, flat, double-beaded, high speed steel drills, produced by rolling, and which drill through light sections satisfactorily are generally used.

This drill stock can be obtained in long lengths and cut-up as needed. It is very strong and stands up to the work under the abuse of cramping and heavy feeds at high speed. It must be held in a special chuck and some skill is required to sharpen properly.

Conclusion

Power track drills find their greatest usefulness where regular programs of track work are in operation. With power bonding drills, signal bonds can be installed as fast as the rails are laid. Cut rails can be drilled for track bolts and joints made safe for traffic with the minimum of lost time. Around terminals or where time is at a premium due to heavy traffic, the power drill permits more work to be done because the final operation of drilling and bolting can be carried out with speed and certainty.

Report of Committee 22—Economics of Railway Labor

G. M. O'Rourke, *Chairman,*
Lem Adams
C. W. Baldridge
E. T. Barrett
E. J. Bayer
F. J. Bishop
W. H. Brameld
E. J. Brown
H. G. Carter
H. A. Cassil
J. I. Catherman
A. B. Chaney
Armstrong Chinn
C. M. Chumley
C. G. Grove
F. L. Guy
C. C. Haire
J. G. Hartley
W. H. Hillis
E. T. Howson
H. E. Kirby
D. A. Kuebler
G. M. Magee
J. B. Martin
J. S. McBride
E. H. McIlheran
J. M. Miller
F. R. Paisley
J. A. Parant*
L. L. Adams, *Vice-Chairman,*
J. S. Parsons
A. E. Perlman
W. G. Powrie
R. L. Schmid
F. S. Schwinn
H. M. Stout
W. H. Vance
E. C. Vandenburgh
J. C. Wallace
Edward Wise, Jr.,
C. R. Wright

Committee.

* Died September 22, 1941.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   No report.

2. Analysis of operations of railways that have made marked progress in the reduction of labor required in maintenance of way work.

   Progress report—presented as information ..... page 230

3. Labor economies to be secured by providing section gangs with labor saving machines and the minimum size of gang to be so equipped.

   No report.

4. Labor economies to be derived from stabilization of roadbed through means other than drainage.

   Final report, presented as information ..... page 233

5. Review and revise factors previously established for equating track values for labor distribution.

   Final report, including table presented for adoption ..... page 235

6. Labor economies possible through the use of highway motor vehicles for maintenance forces.

   Final report, presented as information ..... page 238

7. The relative economy in labor for maintaining ballast deck versus open deck bridges and trestles and approaches thereto.

   No report.

8. Labor economies resulting from periodic spot welding of rail ends as compared with less frequent out-of-face welding.

   Final report, presented as information ..... page 240

9. Labor economies to be derived from keeping vegetation out of ballast.

   Final report, presented as information ..... page 241

THE COMMITTEE ON ECONOMICS OF RAILWAY LABOR,
G. M. O'ROURKE, *Chairman.*

Joseph A. Parant

On September 22, 1941, the members of your committee suffered a severe loss through the death of their associate, J. A. Parant. They take this occasion to endorse the sentiments expressed in the memoir prepared on behalf of the Committee on Economics of Railway Location and Operation which appeared on page 50 of Bulletin 427.

Report on Assignment 2

Analysis of Operations of Railways That Have Made Marked Progress in the Reduction of Labor Required in Maintenance of Way Work

H. A. Cassil (chairman, subcommittee), Lem Adams, E. T. Barrett, F. J. Bishop, E. J. Brown, H. G. Carter, A. B. Chaney, C. C. Haire, J. G. Hartley, E. T. Howson, G. M. Magee, J. S. McBride, E. H. McIlheran, J. A. Parant, A. E. Perlman, W. H. Vance, C. R. Wright.

This is a progress report, presented as information.

A program of widening the roadbed and improving its drainage is ordinarily limited to locations where it is too narrow to properly support additional ballast and where unstable track conditions plainly indicate inadequate drainage. The program now in progress on certain lines of the Great Northern in Minnesota and North Dakota is not so limited, but constitutes an "out of face" rehabilitation of the roadbed which will give it substantially the same characteristics as if it were newly built to the most approved standards of today. This treatment may be compared to the reconditioning of a house or a machine in which the latest improvements are introduced. It is of such interest as to justify bringing it to the attention of the Association.

This committee is not primarily concerned with the methods and equipment employed, but rather with the objectives sought and with the economies in labor that will result. Nevertheless, some mention of the equipment used is pertinent, as such a program is economically feasible only because of the low cost of moving earth that may be attained by the use of modern high-powered off-track equipment.

Local conditions have governed the type of equipment used. In flat country, elevating graders drawn by tractors are used extensively; and the work is finished with tractor-drawn blades. On heavier work, drag lines are used where side borrow is available; otherwise material is hauled in from widened cuts or from distant borrow pits with carryalls, or with dump trucks loaded by crawler-mounted shovels, and is placed and consolidated by means of bulldozers.

Fig. 1.—The Fill Material Was Spread and Consolidated by Means of Bulldozers.

Fig. 2.—Fill Widened by Tractor-Drawn Elevating Grader.

Cuts are widened liberally, not only to provide ample drainage, but to improve snow conditions. No material is wasted, but is used in widening fills or filling low places on the right-of-way. The cut ditches are placed along the toes of slopes and the ground between the track and the ditch is sloped toward the latter at rates varying from 10 horizontal to 1 vertical, to 6 horizontal to 1 vertical.

Slopes of fills are not steeper than 1½ horizontal to 1 vertical and where the material is of an unstable nature, they are as flat as 3 to 1. Ditches along fills are placed as far from the track as possible, with careful attention to gradient and outlet, and the ground between the fill and the ditch is sloped uniformly, as in the cuts, old borrow pits being filled where necessary to accomplish this.

The entire right-of-way is thus utilized to improve drainage, and at the same time it is put in such a smooth and even condition as to permit the use of power mowers

Fig. 3.—The Right-of-Way Was Put in a Smooth and Even Condition to Permit the Use of Power Mowers.

Fig. 4.—The Ditches Were Placed as Far from the Track as Possible.

throughout, or the cutting of hay by adjacent land owners. It will also permit the use of off-track power equipment for cleaning ditches in future maintenance. The grading has been done for certain passing track extensions, and cuts have been widened to improve the view at a number of highway grade crossings. The cubic yards moved per mile has varied from 2,850 to 8,000. The work has been done by contract at low cost, because of the efficient off-track equipment used.

On the line between Duluth and Minneapolis, the maximum curvature has been reduced to 1 deg. 30 min. in connection with this program, although the previous curvature was not especially sharp. This and the other features of the program, together with

ballasting and new 112-lb. rail, will permit a substantial increase in the speed of both passenger and freight trains on this line.

This program has been under way for about four years and is still in progress. Even when completed, it will obviously not be possible to allocate to it any specific share of the benefits that will accrue, as distinguished from those resulting from the track improvements. However, because of unstable track conditions and narrow banks at many points, a considerable part of the program was absolutely necessary as a foundation for track betterment. Those in close touch with the work are convinced that this complete revamping of the roadway has already resulted in improved operating conditions and substantial economies.

Measures such as those employed by the Great Northern in out-of-face operations, as described above, have much to commend them, both as a means for strengthening the track structure for today's more exacting service and for reducing the labor cost of maintenance of the track to the standards necessary therefor.

Report on Assignment 4

Labor Economies to Be Derived from Stabilization of Roadbed Through Means Other Than Drainage

E. H. McIlheran (chairman, subcommittee), L. L. Adams, E. J. Bayer, H. G. Carter, J. I. Catherman, A. B. Chaney, C. M. Chumley, C. G. Grove, W. H. Hillis, E. T. Howson, F. R. Paisley, J. S. Parsons, R. L. Schmid, H. M. Stout, W. H. Vance, J. C. Wallace, Edward Wise, Jr.

The following report is submitted as information.

This committee sent a questionnaire to 48 railroads, representing about 197,000 miles of road, to ascertain the various methods other than drainage that are used to stabilize roadbeds, the cost of such work and the saving in labor derived therefrom. Engineering officers of 32 railroads, representing about 125,200 miles of road, replied; 11 of them reported that they had used no means other than drainage to stabilize the roadbed; 5 reported that they had done some pole driving but supplied no statistics; and 16 furnished data for use in this report.

The methods reported are: Driving cull or old crossties or short poles in cuts or low fills; driving poles, piling or scrap rail in the shoulders of embankments; placing concrete slabs or wood mats on top of the roadbed; forcing cement grout into the roadbed and constructing banquettes along the toe of embankment slopes or widening the base of the embankments. These methods, with descriptions, costs and estimated savings are:

Driving Poles in Cuts or Low Fills

Where the track continues to settle and heave and requires more than ordinary spotting, cull or old crossties or poles 7 to 10 in. in diameter and 8 to 12 ft. long, or any timber of sufficient strength to withstand driving, are driven not to exceed 6 in. from the ends of the track ties, with their tops 6 to 12 in. below the bottom of the track ties and spaced 18 to 21 in. apart.

Pole driving machines have been constructed for this work which can drive 60 ties an hour and can be removed from the track in 3 min. It is the usual practice to work

these machines in pairs, driving on opposite sides of the track. Reports were received on the driving of 326.26 miles of cuts and fills with ties and poles at a total cost of $1,059,613 or an average of $0.615 per ft. of track and an estimated annual saving of $333,880 or about 31½ percent of the investment.

One railroad, operating 4,417 miles of road, reported driving 71.38 miles of track at a cost of $97,134 or about $1,361 per mile, and advised that a record was kept of the cost to maintain "heavey" track for a period of 9 to 16 months; and the average cost was $2,280 per mile per annum. After stabilizing the subgrade by driving poles, the cost of maintenance was reduced to $411 per mile per annum or a saving of $1,869 per mile per year for labor costs only.

Another railroad reported on driving 95.63 miles of track and advised, in part, as follows:

> We do not have an estimate on the saving in labor resulting from this driving except for the first test section which was driven in 1939. This covered 2.31 miles on a light fill ....., the installation cost of which was $6,664 and the saving in track labor $3,550 or a rough average of $1,500 a mile per year.
>
> It is safe to assume that the balance of track we have driven as above will produce a saving of approximately half this amount per mile per year.

Driving Poles, Piling or Scrap Rail in the Shoulders of Embankments

Poles, piling and scrap rail have been driven in the shoulders of embankments, varying in height from 8 to 40 ft., both to prevent settlement of the track and to cure sliding fills. The poles and piling have been driven from 9 to 15 ft. from the center of track, spaced from 3 to 5 ft. apart; and in some of the installations, piles on the opposite sides of the track have been tied together by rods placed through the embankment. Some of the installations have a waling strip of heavy timber on the outside of the piles near the top, and the tie rods run through these strips.

The scrap rails are used where the underlying foundation is rock and wood piling cannot be driven. The rails are driven in the shoulders of the embankment and spaced as required by conditions. Two rails are placed horizontally against the outside of the driven rails near their tops to serve as waling strips, and the lines of driven rails on the two sides of the track are tied together by means of scrap rails driven transversely through the fill, the ends of these rails being split with a cutting torch so that the split ends may be bent to form loops around the waling strips.

It was reported that a total of 20.63 miles of track has been driven with poles and piling at a cost of $293,714 or $2.69 per ft. of track, with an estimated annual saving of $79,056, or about 26.9 percent of the investment.

It was reported that 5.49 miles of track has been driven with scrap rail at a cost of $254,915 or $8.79 per ft., with an estimated annual saving of $67,069 or about 26.3 percent of the investment.

Concrete Slabs

Three railroads reported on the installation of concrete slabs. One installation of 8,560 ft. of single track was made about 30 years ago in an unstable cut, before the track was laid, at a cost of about $5.60 per track ft. Some of this slab is 12 in. thick reinforced with steel wire mesh and some is 15 in. thick reinforced with rods at the top and bottom. There has been no trouble from the roadbed since constructing the slab.

Another railroad reported on the placing of concrete slabs under 4,625 ft. of track at a cost of $18,470 or about $3.99 per track ft. with an estimated annual saving of

about 30 percent. These slabs were 10 by 12 ft., 6½ in. thick at the center sloping to 5½ in. at the edges, reinforced top and bottom with steel rods and were manufactured in a casting yard and thoroughly cured before they were placed.

The other railroad reported construction of slabs under 2,650 ft. of track at a cost of $37,281 but furnished no estimate of the saving.

Wood Mats and Cement Grout

One railroad reported on the use of cypress timber mats constructed of 3 by 10 in. plank 14 ft. long laid across the embankment on top of the subgrade with 2 by 10 in. timbers laid lengthwise on top of the 3 by 10 pieces. There was reported 6,642 ft. of track protected at a cost of $2.69 per track ft. with an estimated annual saving of 30 percent on the investment.

Another railroad reported the use of cement grout forced into the roadbed by air pressure. There were 472 ft. of track so treated at a cost of $1,650 or about $3.49 per track ft. at an estimated annual saving of $987 or about 60 percent on the investment.

Banquettes

These consist of an additional embankment along the toe of the embankment slope to add stability and keep drainage away from the toe of the slope. Several railroads stated that this method was used, but no data were furnished.

Report on Assignment 5

Review and Revise Factors Previously Established for Equating Track Values for Labor Distribution

H. E. Kirby (chairman, subcommittee), C. W. Baldridge, E. T. Barrett, E. J. Bayer, E. J. Brown, H. G. Carter, F. L. Guy, C. C. Haire, J. G. Hartley, G. M. Magee, J. S. McBride, J. M. Miller, R. L. Schmid, F. S. Schwinn, E. C. Vandenburgh, J. C. Wallace, C. R. Wright.

This is a final report presented as information, with a table and conclusions that are offered for adoption and publication in the Manual.

Your committee has reviewed the subject of equated track values as it has been presented in previous studies by the Association. The subject was first undertaken by the Committee on Track in connection with an assignment on Economics of Track Labor (Proceedings for 1914, Vol. 15, page 590). Subsequent studies by the Committee on Economics of Railway Labor were published in the Proceedings, Vol. 23, page 685; Vol. 29, page 498; and Vol. 30, page 1136. Aside from the first work by the Track committee, related investigations also have been made by the Committee on Economics of Railway Operation, the results of its work being published in the Proceedings, Vol. 26 (Method of Determining Proper Allowance for Maintenance of Way Expense due to Increased Use and Increased Investment) and in Vols. 39, 40 and 41 (Methods and Formulas for the Solution of Special Problems).

Essentially all of the data procured by this committee in an effort to revise on a sound basis the table of mileage and track property equivalents most commonly used, and which appears in the Proceedings as a part of the three previous reports on this subject, were received in response to inquiries addressed to a great number of railroads

during the past two years. Opinion was found to be about equally divided as to the necessity and advisability of attempting a revision at this time. However, examination of information given by the responding railroads indicates that use is made of the present table of equivalents to the following extent:

29 percent use the AREA table of values
11 percent use in part the AREA table of values
23 percent use a set of values formulated by themselves
37 percent use no formula or set of values.

Due to the difficulty of mathematical treatment of the numerous imponderables and variables inherent in the problem, a solution by other than empirical methods was found to be impracticable. The committee was fortunate in getting from its correspondents what is considered to be a fairly complete discussion, with some factual data and statistics covering many of the factors involved. This material was weighted, averaged and analyzed, as a result of which the following table of relative values (in the sense of this assignment) is offered:

First main track, mile	1.00
Second main track, mile	0.83
Third and fourth main track, mile	0.75
Branch line track, mile	0.49
Passing and thoroughfare track, mile	0.43
Yard and side track, mile	0.32
Main track switch, each	0.07
Side track switch, each	0.05
Railroad crossing, each	0.10
Paved street or highway crossing, each	0.07
Unpaved highway crossing, each	0.03
Unimproved road crossing, each	0.01

These values are to be compared with the values given in the table on Manual page 21–10 for use in determining the added maintenance requirement due to investment, which are as follows:

1 mile of first main	= 1.00	mile
1 " " each additional main	= 0.80	"
1 " " sidings	= 0.50	"

The proposed values compare as follows with the table of equivalents published in Proceedings, Vol. 23, page 685:

	Track Equivalents Developed	*Relative Values*		
	1921	*1921*	*As Revised 1941*	*Percent Change*
First main track, mile	1.00	1.00	1.00	0.0
Second main track, mile	1.15	0.87	0.83	— 4.6
Other main track, mile	1.33	0.75	0.75	0.0
Branch line track, mile	2.00	0.50	0.49	— 2.0
Passing and thoroughfare track, mile	2.00	0.50	0.43	—14.0
Yard and side track, mile	3.33	0.30	0.32	+ 6.7
Main track switch, each	12	0.084	0.07	—16.7
Side track switch, each	20	0.050	0.05	0.0
Railroad crossing, each	10	0.100	0.10	0.0
Paved street or highway crossing, each	12	0.084	0.07	—16.7
Unpaved highway crossing, each	25	0.040		
	50	0.020	0.03	...
Unimproved road crossing, each	..	....	0.01	...

In addition to the items given in this table of values, some railroads have established ratings covering other factors. These include:

1. Various grades of first main track (in one case, five grades)
2. Various grades of branch line track
3. Pusher grades
4. Tunnel track
5. Bridges, grade, over and undergrade
6. Station platform track
7. Water pans
8. Railroad crossings, steam and electric, various sizes
9. Single and double slip switches
10. Interlocking plants
11. Insulated joints
12. Allowance for effect of curvature, based on (1) diminishing units of track corresponding to increasing degree of curve with decreasing rate of speed, in relation to one mile of tangent track with speed at 70 m.p.h., or, (2) given amounts of central angle, diminishing in inverse ratio to degree of curve, in relation to one equated track mile.

The importance of these items is recognized generally, but their use as definite equivalents is confined to a slight minority of the railroads. Hence, the limited data available were considered to be insufficient to form the bases of established values. For these reasons, also, it appeared to be impracticable to attempt to fix the values of the following items: ditching, removing snow, derails, fences, station grounds, water and fuel stations, stock pens, and other facilities which also are included by some of the carriers.

It may be of interest to observe the differences in several of the items given in the table of values, as between the values formulated 20 years ago and revisions developed by this investigation. Except for comparatively slight decreases in the relative values of second main and branch line track, it will be noted that the principal changes in track relationships are a 14 percent decrease for passing and thoroughfare tracks and a 6.7 percent increase for yard and side track. It seems reasonable to expect that, while heavier rail, longer-life ties, larger tie plates and other improved materials will be put into main tracks first, their use ultimately will extend to all other tracks, and that when this condition is achieved there should be no great change in the values of the several track classifications, and also, that in relation to each other a fairly constant ratio will obtain, except as influenced by changes in the speed and use factors.

Reductions will be noted in the case of main track and side track switches. These reflect improved design, extended life of frogs and switch points by welding and grinding, together with the use of special designs, protective devices and heavier plates with adjustable braces. Maintenance of guard rails is likewise affected by improvement in design and use of heavier plates with adjustable clamps.

Railroad crossings show the comparatively slight decrease of 3 percent in relative value, a somewhat larger decrease being prevented by steady increases in rates of speed and in axle loadings. Much noteworthy improvement has been made in the design, construction and maintenance of railroad crossings, but much of the potential maintenance savings apparently has been offset by the effect of increased impact.

The decrease of 13.1 percent in relative value of paved street or highway crossings can be attributed to the present use of more durable types of construction, a trend that is significant in the face of the enormous increase in motor traffic. The magnitude of this increase can be seen from the fact that motor vehicle registration (automobiles and

trucks), excluding publicly owned vehicles in the United States, has risen from 9,231,941 in 1920 to 32,025,365 in 1940.

It will be observed that ditching has been omitted from definite evaluation, although this item has been subject to great change during the past few years. In fact, consideration of the various methods now in use showed such lack of uniformity in method and results that anything approaching a fixed value seemed impracticable. Ditching, which formerly was almost exclusively a manual operation, is now performed largely by various mechanical means in which labor has a somewhat lesser part.

Your committee appreciates the fact that, in addition to the best summation of equated mileage for any given part of a railroad, consideration must be given several other variables. Most important are the factors of speed and use, and the interrelation of these and the present condition of the property with the standard condition of maintenance to be attained. Present condition of the property embraces subsoil and soil conditions, drainage, curvature, grades, types of motive power, nature of traffic, climatic and other conditions local or peculiar to the territory under study.

During the past two decades there have been important developments which have required consideration in this study. The technological advances of practically all industries have also extended to railroads, with the result that machinery now is used to some extent in nearly all maintenance operations. Hence, the labor ratio varies with the extent of this use, but not directly. Budget planning necessarily takes this into account. Also, there is the increased efficiency in maintenance methods, brought about by economic conditions during this period and by special study on the part of the railroads.

Conclusions

1. The table of comparative track values is recommended for general guidance in allocating labor on territories where all conditions are approximately alike, and its use will aid in distributing maintenance allowances to greater advantage than would otherwise be the case.

2. No table of track values can be sufficiently specific to meet all conditions of railways or portions of railways having varying traffic, physical, or other basic characteristics. Hence, the use of the table is subject to limitations when so applied.

It is recommended that these conclusions and the revised table of relative track values presented on page 236 be adopted for publication in the Manual.

Report on Assignment 6

Labor Economies Possible Through the Use of Highway Motor Vehicles for Maintenance Forces

J. A. Parant (chairman, subcommittee), C. W. Baldridge, E. T. Barrett, E. J. Bayer, F. J. Bishop, W. H. Brameld, E. J. Brown, J. I. Catherman, A. B. Chaney, C. G. Grove, F. L. Guy, J. G. Hartley, J. M. Miller, A. E. Perlman, W. G. Powrie, F. S. Schwinn, H. M. Stout, C. R. Wright.

This report is presented as information.

The use of highway motor vehicles for maintenance work on the railroads, in general, has grown substantially during the past 15 years. The savings per unit per year which various railroads have reported to the committee are substantial when compared with the investments required.

In its study the committee finds, however, that the predominance of use of these highway vehicles by the railroads is in large busy terminals and congested main line territory where the movement of men, when confined to either work trains, track motor cars and trailers, or existing train service, results in relatively high percentages of non-productive time. Furthermore, in territory of this nature, the handling and transportation of materials and tools by the old methods results in slow deliveries, excessive transportation costs and delays to work.

The savings possible in maintenance of way and structures labor by the use of these highway vehicles depends entirely upon the extent to which the existing conditions on any railroad lend themselves to their full and efficient use. The vehicle selected should, when possible, be of a design and type that will adapt itself to the many operations in maintenance work.

Answers to questionnaires, in all cases, bring out the value of this equipment in emergencies and stress the facility with which crews, tools and materials can be transported in cases of accidents, storms, floods, broken rails, etc. Even though savings that are possible in handling these and other emergencies, through the mobility and speed of the units, may not reflect in maintenance of way labor accounts, nevertheless, their use and possibilities under these conditions are many and should be considered in the picture as a whole.

Some of the channels through which the savings materialize are as follows:

Advantages

1. No delays in starting for work in the morning or leaving for headquarters at night due to waiting for trains, clearance orders, lineups, or yard congestion to clear up.
2. It is possible to carry a full complement of tools in a properly equipped truck.
3. Distribution of material and supplies direct to crews, eliminating unloading from cars and reloading on push cars for delivery to the job.
4. Speeding up deliveries of material for work under way, preventing delay to crews.
5. Replacement of motor cars where trucks are assigned to crews.
6. Saving in work train service and car days.
7. Minimizing non-productive time due to clearing for trains while enroute to and from work or stopping of motor car when trains are passing.
8. Highway motor vehicles may be operated at higher speed than motor cars.
9. Expedites deliveries of men and materials in emergencies.
10. In heavy snow storms trucks are especially efficient in eliminating rehandling of snow and in the delivery of men, tools and supplies. During severe storms there is often a scarcity of trucks for hire.
11. Repairs to interlocking plants, crossings, crossing gates, buildings, platforms, driveways, water columns, pipe lines, plumbing, frogs and switches and other work are facilitated materially by the use of trucks increasing the output of these crews as much as 25 to 50 percent.
12. In floods and washouts trucks will transport men and materials to points not accessible by motor car or work train.
13. In some instances trucks have made it possible to cut down the number of maintenance crews.
14. Truck cranes make it possible to handle material for bridge and building work about wharves, docks, highway bridge and other structures and to eliminate rail mounted equipment and work trains, at points where it is impossible or, in other cases, expensive to use on-rail equipment.

Disadvantages

There are certain disadvantages in substituting highway motor vehicles for the present methods some of which are as follows:

1. Loss of track patrol and inspection which would be performed by crews on motor cars.
2. Inability to utilize trucks to the maximum.

Conclusions

Substantial savings are possible in maintenance of way labor through the use of highway motor vehicles where conditions are conducive to and are favorable for their employment. In such locations savings of $500 to $3,600 per unit per year have been reported to the committee.

Report on Assignment 8

Labor Economies Resulting from Periodic Spot Welding of Rail Ends as Compared with Less Frequent Out-of-Face Welding

W. G. Powrie (chairman, subcommittee), L. L. Adams, Lem Adams, C. W. Baldridge, F. J. Bishop, W. H. Brameld, H. G. Carter, H. A. Cassil, Armstrong Chinn, C. G. Grove, J. B. Martin, J. M. Miller, J. A. Parant, J. S. Parsons, A. E. Perlman, F. S. Schwinn, H. M. Stout, Edward Wise, Jr.

This is a final report, presented as information.

Information has been secured from 34 railroads to show the manner in which rail end welding is handled on those lines and the reasons for so handling. Thirty-one of the railroads reporting advise that they carry on rail end welding work in out-of-face programs but also state that they have spot welding work to do which may amount to from 5 to 50 percent of the total rail end welding done. Several roads report that out-of-face welding of rail ends is undertaken where 50 percent or more of the rail ends are battered in excess of 0.035 in. This degree of batter prompts the welding program, but welding is not limited to the rail ends battered to this extent. The plan followed is that all rail ends which in the judgment of the head welder will be improved are welded at that time.

Only three of the railroads reporting carry out rail end welding work by the periodic spot welding plan only. These three roads cite the following conditions as warranting this practice: (1) Where it becomes necessary to build up the rail ends needing most urgent attention, pending the time when funds, welding crews or equipment are available to carry out out-of-face programs, and (2) where all rail ends previously have been built up by welding out-of-face and the work remaining to be done consists of repairing an occasional rail joint due to an individual rail replacement or chipped rail end.

The reporting roads agree that the labor cost for building up joints is less per joint for out-of-face welding where there are more joints to weld in a given distance than there would be in spot welding work. Figures to substantiate this were not submitted; but some of the reasons assigned were that the out-of-face program provides sufficient work to organize a crew of the most efficient size and properly equipped, reducing the time otherwise spent in moving, and that such an operation can be more readily supervised. Frequently out-of-face welding is undertaken in conjunction with angle bar renewals or some other heavy maintenance work.

The rebuilding of rail ends undoubtedly brings about reduced track maintenance costs and improves the riding quality of the track. This part of the subject is covered in a report published in the AREA Proceedings for 1938, Vol. 39, pages 587 and 588, under the heading of "Economies in Track Labor to be Effected in Maintenance of Joints by Welding and Use of Reformed Bars." The reduction in rail joint maintenance costs effected by rail end welding should vary little regardless of whether the work is carried on by spot welding or by out-of-face programs, assuming that in either case the welding is done when it should be, which is to be determined by the individual railroad.

Conclusions

Labor to spot weld rail ends periodically costs more per joint welded than it does when the welding can be done in out-of-face programs. The economies in track maintenance effected by welding rails are the same if the work is done in either the periodic spot welding manner or by the out-of-face plan if the welding work is done when it is required.

Report on Assignment 9

Labor Economies to Be Derived from Keeping Vegetation Out of Ballast

C. R. Wright (chairman, subcommittee), E. J. Bayer, W. H. Brameld, E. J. Brown, J. I. Catherman, C. M. Chumley, F. L. Guy, W. H. Hillis, H. E. Kirby, D. A. Kuebler, J. B. Martin, F. R. Paisley, J. S. Parsons, W. G. Powrie, H. M. Stout, W. H. Vance, E. C. Vandenburgh, J. C. Wallace.

This is a final report, presented as information.

The Association has approved and there is included in the Manual, page 22–5, the following statement: "In the track, the elimination of vegetation facilitates drainage, increases the life of ties, reduces the fouling of ballast and otherwise decreases the cost of track maintenance." This statement implies that labor can be saved by keeping vegetation out of the ballast. The extent to which this is true will depend upon conditions existing on a particular railroad.

During the past 11 years most railroads have been compelled to reduce expenditures for cleaning ballast and eliminating vegetation. With better earnings and increased expenditures for track maintenance, there may be opportunities to reduce expenditures for track labor by eliminating vegetation in the ballast. One railroad reports that it has continued the use of chemical weed killer on a considerable mileage of track for the past 14 years at a cost of as much as $28 to $30 per mile of track per year, even though its total allowance for track maintenance was reduced during that period, for the reason that on a part of its line the cost of hand weeding was as high as $75 per mile of track.

In the report of this committee, Vol. 37, pages 236–250, there is very complete information concerning the control of vegetation in the roadbed, including an account of the methods to be used for eliminating vegetation from the ballast, the costs of the work and the results that may be expected.

The items of track labor most affected by vegetation in the ballast are as follows:

1. Renewing Cross Ties

The labor for renewing cross ties is increased where the track ballast is full of vegetation. The amount of labor required to renew ties in this kind of track will be

increased from 10 percent to 50 percent above what is required to install the same ties in track with clean ballast. One railroad reports the cost of installing ties in ballast full of vegetation as 75 cents per tie. After placing new cinder and gravel ballast, this cost was reduced to 40 cents per tie. A study of the costs of the complete operation would be necessary to determine what saving of labor was affected.

2. Labor Maintaining Ballast

Vegetation allowed to grow in the ballast shortens its life, eventually making renewal or replacement necessary. The general practice on most railroads is to renew ballast on branch lines and side tracks where the allowance for maintenance is not sufficient to include labor for eliminating vegetation. For the period of years that the ballast is not cleaned either there is a gradual increase in expenditures for maintenance or the standard of maintenance is lowered. Eventually the value of the ballast will be destroyed, partially by the vegetation, and the increased cost of maintenance will make it necessary to renew the ballast. The cost of labor and ballast material, the character of the railroad and the cost of keeping vegetation out of the ballast will determine what saving of labor could be made if vegetation was kept out of the ballast.

3. Maintaining Track Drainage

Vegetation in the ballast blocks drainage, resulting in churning of the joints and loose ties. As the amount and density of vegetation increases, the drainage function of most ballast material is gradually destroyed; and this condition produces rough track which eventually requires that additional maintenance labor be used or that the ballast be cleaned or renewed. Information obtained by the committee indicates that with the ballast foul with vegetation, there is an increase of approximately $30 per mile per year in the cost of maintaining track in good surface as compared with the cost of maintaining similar track that is free of vegetation.

Conclusion

(a) The committee has found no data to show the extent to which actual savings in labor result from keeping vegetation out of the ballast.

(b) To determine the extent of the labor savings that will result by reason of keeping vegetation out of the ballast requires careful study of the characteristics of the railroad and the amount of and cost of the track labor employed.

Report of Committee 7—Wood Bridges and Trestles

R. P. Hart, *Chairman,*
H. Austill
M. W. Beach
A. E. Bechtelheimer
W. A. Blackwell
S. Blumenthal
H. F. Bober
R. E. Caudle
A. B. Chapman
H. M. Church
L. B. Craig
F. H. Cramer
G. S. Crites
J. F. Dobson
D. H. Dowe
Hugh Everett, Jr.
S. F. Grear
G. V. Guerin, Jr.
G. A. Haskins
H. C. Heinlen
C. J. Hogue
C. S. Johnson
J. V. Johnston
W. D. Keeney
H. T. Livingston
W. A. Oliver, *Vice-Chairman,*
J. E. Myer
W. O. Nelson
J. A. Newlin
W. H. O'Brien
W. L. Peoples
G. W. Rear
Arthur Ridgway
W. C. Schakel
L. W. Smith
William Walkden
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   No report.

2. Simplification of grading rules and classification of timber for railway uses, collaborating with other organizations interested.

   No report.

3. Overhead wood or combination wood and metal highway bridges, collaborating with Committee 15—Iron and Steel Structures; and conferring with proper committee of the American Association of State Highway Officials.

   No report.

4. Specifications for design of wood bridges and trestles.

   Report offering Specifications for Design of Wood Bridges and Trestles for Railway Loading, submitted for adoption ..... page 244

5. Bearing power of wood piles, with recommendations as to methods of determination, collaborating with Committee 8—Masonry.

   No report.

6. Recommended relationships between the energy of hammer and the weight or mass of pile for proper pile driving, to include concrete piles, collaborating with Committee 8—Masonry.

   No report.

7. Design of timber structures:
   (a) To give longer life with lower cost of maintenance;
   (b) For heavy loading.

   No report.

8. Specifications and design of fastenings for timber structures, including metal joint connectors.

No report.

The Committee on Wood Bridges and Trestles,
R. P. Hart, *Chairman.*

Report on Assignment 4

Specifications for Design of Wood Bridges and Trestles

A. B. Chapman (chairman, subcommittee), A. E. Bechtelheimer, S. Blumenthal, H. M. Church, S. F. Grear, W. O. Nelson, J. A. Newlin, W. A. Oliver, G. W. Rear, W. C. Schakel, L. W. Smith.

Last year your committee presented as information a tentative draft of Specifications for Design of Wood Bridges and Trestles for Railway Loading, and requested comments and criticisms thereon. These specifications have been revised and are now submitted with the recommendation that they be adopted and published in the Manual.

SPECIFICATIONS FOR DESIGN OF WOOD BRIDGES AND TRESTLES FOR RAILWAY LOADING

FOREWORD

The following specifications contemplate the use of sound piles and stress-grades of structural timbers conforming to AREA specifications, particularly Specifications for Structural Timbers, and Notes on Use of Stress-Grades. Stress-grades, working unit stresses and principles of design, except for treated timber, conform to recommendations of U. S. Forest Products Laboratory, based on exhaustive tests. Working unit stresses adopted by the Engineer should conform to the stress-grades to be used in the structure, making due allowance for exposure and moisture conditions, see Table 705.

For special provisions relating to grading of bridge timbers used in tension, post sizes used in bending, and beams continuous over two or more spans, see Notes on Use of Stress-Grades.

Seasoned timber acquires a permanent set under long continued loading. This set is about equal to the short time deflection, using moduli of elasticity as given in the tables. The ultimate deflection under long-continued loading will thus be about twice the short time deflection. Green or freshly treated timber will sag much more as it seasons.

I GENERAL FEATURES OF DESIGN

101. Materials

Timber graded under AREA Specifications for Structural Timbers is expected to be used in structures designed in accordance with the provisions which follow. Where portions of the structure consist of structural steel, reinforced concrete or masonry, the current AREA specifications relating to structures of these materials will apply, with allowances for impact provided in those specifications.

102. Clearances

The clearances on straight track shall not be less than those shown in Fig. 719. On curved track the clearance shall be increased to allow for the overhanging and the tilting of a car 85 feet long, 60 feet between centers of trucks, and 14 feet high.

The superelevation of the outer rail shall be as specified by the Engineer. Where legal requirements provide greater clearances, they shall govern.

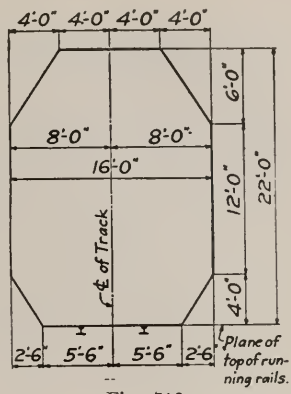


Fig. 719.

103. Piles and Post Footings

Piles shall be driven to the required bearing capacity in accordance with AREA specifications for driving wood piles. Posts shall be provided with adequate foundation to support the loads superimposed upon them.

104. Bents

Bents shall consist of a sufficient number of piles or posts, correctly spaced, so that no member in any bent will be overstressed under any condition of loading. For the purpose of computing stresses in the bents their spacing shall be considered as the distance center to center of caps thereon. An approximate analysis to determine the division of load among the several piles of a bent is given in the chart, Fig. 720.

105. Stringers

The span length, for the purpose of computing bending stresses in the stringers, shall be assumed as the clear distance face to face of bearings plus 6 inches; except that, if continuity is figured on, the intermediate support shall be taken at the center of the support.

Stringers shall be selected to provide:

(a) Depth, preferably, not less than $\frac{1}{12}$ of the span.
(b) Width, not less than ⅓ of the depth.

106. Ties

Crossties shall be of adequate size to distribute the track load to all stress-carrying stringers, with the stringers in a group placed to effect, as nearly as practicable, equal distribution of track loads. An approximate analysis to determine the division of rail load to several stringers is given in the chart, Fig. 721.

Each tie shall be designed to carry not less than ⅓ of the maximum axle load, as well as to provide sufficient stiffness to properly distribute loads to the stringers. Ties shall be secured against bunching, and the maximum clear space between them, on open deck bridges, shall be 8 inches.

II LOADS AND STRESSES

201. Loads Considered

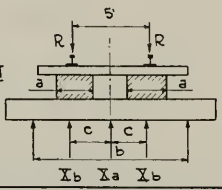
The following loads shall be considered:

(a) Dead load.
(b) Live load.
(c) Centrifugal force.

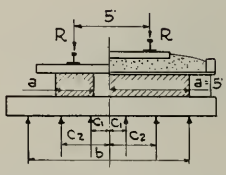
Distribution of Load to Piles of Timber Trestles

R = Live load taken by one bent (1 rail)
X_a = Load taken by each inside pile.
X_b = Load taken by each intermediate pile.
c, c_1, c_2, = Distance of inner piles from ℄ of bent, inches.
b = Distance between outer piles, inches.
a = Width of stringer bearing on cap, inches. (load assumed uniform.)
For ballast floor bridges a may be taken as 60"
I = Moment of inertia of cap, inches^4.
L = Effective length of piles, inches. Take as exposed length + ½ penetration.
q_a, q_b = Deflection of cap due to R = 1. (without X_a and X_b acting.)
r_a, r_b = Deflection of cap due to X_a = 1, acting alone.
S_a, S_b = Deflection of cap due to X_b = 1, acting alone.
U = Shortening of pile due to unit load on pile, inches.
(Pile assumed 14" diam. at top, taper to 10" diam. at 30' (A.R.E.A. Spec.)

5-Pile Bent



6-Pile Bent



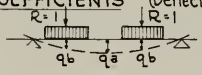
Deflection Equations - For consistant deflections of cap and shortening of piles.

(1) $(r_a + \frac{3}{2}U)X_a + (S_a + U)X_b = (q_a + U)R$.
(2) $(r_b + \frac{1}{2}U)X_a + (S_b + 2U)X_b = (q_b + U)R$

(1) $(r_a + 2U)X_a + (S_a + U)X_b = (q_a + U)R$
(2) $(r_b + U)X_a + (S_b + 2U)X_b = (q_b + U)R$

Deflection Coefficients (Deflections of cap, due to unit loads.)

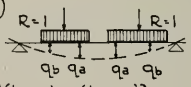
Due to Loads R = 1



$$q_a = \frac{1}{24EI}\left[b^3 - \frac{b a^2}{2} - 6(30)^2 b + 30a^2 - 4(30)^3\right] \quad (3)$$

$$q_b = \frac{1}{24EI}\left[(3b^2 - a^2 - 12(30)^2)(\tfrac{b}{2} - c) - 4(\tfrac{b}{2} - c)^3 + \tfrac{1}{a}(\tfrac{a}{2} + 30 - c)^4\right] \quad (4)$$

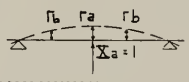
Due to Loads R = 1



$$q_a = \frac{1}{24EI}\left[(3b^2 - a^2 - 12(30)^2)(\tfrac{b}{2} - c_1) - 4(\tfrac{b}{2} - c_1)^3 + \tfrac{1}{a}(\tfrac{a}{2} + 30 - c_1)^4\right] \quad (3)$$

q_b – Substitute c_2 for c_1 in equation above ....(4)

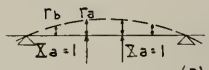
Due to Pile Load $X_a = 1$



$$r_a = \frac{1}{48EI} b^3 \quad (5)$$

$$r_b = \frac{1}{48EI}(\tfrac{b}{2} - c)\left[3b^2 - 4(\tfrac{b}{2} - c)^2\right] \quad (6)$$

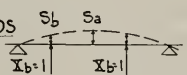
Due to Pile Loads $X_a = 1$



$$r_a = \frac{1}{6EI}(b + 4c_1)(\tfrac{b}{2} - c_1)^2 \quad (5)$$

$$r_b = \frac{1}{6EI}(\tfrac{b}{2} - c_2)\left[3b(\tfrac{b}{2} - c_1) - 3(\tfrac{b}{2} - c_1)^2 - (\tfrac{b}{2} - c_2)^2\right] \quad (6)$$

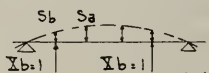
Due to Pile Loads $X_b = 1$



$$S_a = 2r_b \quad (7)$$

$$S_b = \frac{1}{6EI}(b + 4c)(\tfrac{b}{2} - c)^2 \quad (8)$$

Due to Pile Loads $X_b = 1$



$$S_a = r_b \quad (7)$$

$$S_b = \frac{1}{6EI}(b + 4c_2)(\tfrac{b}{2} - c_2)^2 \quad (8)$$

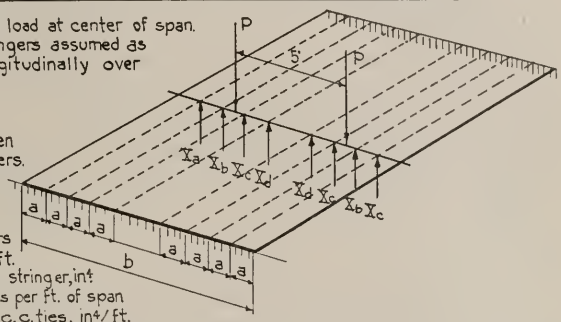
Pile Shortening Due to unit load on pile $U = \frac{9.55}{E}\left(\frac{1}{14 - .133L} - \frac{1}{14}\right)$ ....(9)

Application (1) Substitute design dimensions in equations (3) to (9) incl.
(2) Substitute these coefficients in equations (1) and (2)
(3) Solve equations (1) and (2) for X_a and X_b, giving loads on all inner piles. Remainder of rail loads taken by outer piles.

Fig. 720.

Distribution of Load to Stringers of Timber Trestles

Distribution based on axle load at center of span. Application of load to stringers assumed as parabolic distribution longitudinally over middle half of span.



P = Wheel load

X_a, X_b, X_c, etc. = load taken by successive inner stringers.

L = Span of stringers, ft.

b = distance between centers of outer stringers, ft.

a = distance between centers of successive stringers, ft.

I_s = Moment of Inertia of one stringer, in⁴

I_T = Moment of Inertia of ties per ft. of span = I of one tie ÷ distance c.c. ties, in⁴/ft.

d_1, d_a, d_{aa}, ect., = deflection coefficients (See sketches below.)

Deflection Equations

For consistant deflections of tie and stringers at center of span.

$$\left(2d_1+\tfrac{3}{L}d_{aa}\right)X_a+\left(d_1+\tfrac{3}{L}d_{ba}\right)X_b+\left(d_1+\tfrac{3}{L}d_{ca}\right)X_c+\left(d_1+\tfrac{3}{L}d_{da}\right)X_d=\left(d_1+\tfrac{3}{L}d'_a\right)P \quad \ldots (1)$$

$$\left(d_1+\tfrac{3}{L}d_{ab}\right)X_a+\left(2d_1+\tfrac{3}{L}d_{bb}\right)X_b+\left(d_1+\tfrac{3}{L}d_{cb}\right)X_c+\left(d_1+\tfrac{3}{L}d_{db}\right)X_d=\left(d_1+\tfrac{3}{L}d'_b\right)P \quad \ldots (2)$$

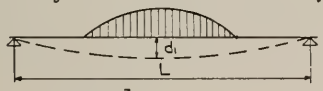
$$\left(d_1+\tfrac{3}{L}d_{ac}\right)X_a+\left(d_1+\tfrac{3}{L}d_{bc}\right)X_b+\left(2d_1+\tfrac{3}{L}d_{cc}\right)X_c+\left(d_1+\tfrac{3}{L}d_{dc}\right)X_d=\left(d_1+\tfrac{3}{L}d'_c\right)P \quad \ldots (3)$$

$$\left(d_1+\tfrac{3}{L}d_{ad}\right)X_a+\left(d_1+\tfrac{3}{L}d_{bd}\right)X_b+\left(d_1+\tfrac{3}{L}d_{cd}\right)X_c+\left(2d_1+\tfrac{3}{L}d_{dd}\right)X_d=\left(d_1+\tfrac{3}{L}d'_d\right)P \quad \ldots (4)$$

For Eight Stringers, use equations (1), (2), (3) omit X_d terms.
For Six Stringers, use equations (1), (2), omit X_c, X_d terms.

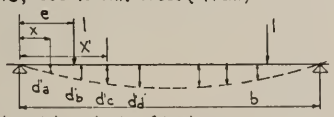
Deflection Coefficients (Deflections due to unit loads).

Stringer, due to total load of unity.



$$d_1 = \frac{1194\ L^3}{61{,}440\ E\ I_s}$$

Tie, due to unit loads (at rails)



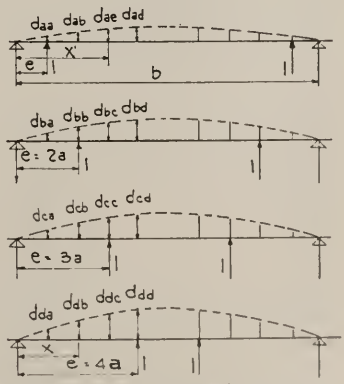
At points outside of load

$$d' = \frac{x}{6EI_T}\left(3b\cdot e-3e^2-x^2\right)$$

At points inside of load.

$$d' = \frac{e}{6EI_T}\left(3bx'-3x'^2-e^2\right)$$

Tie, due to unit loads at stringers



Use equations to left for deflections.

Fig. 721.

(d) Lateral force due to wind load and nosing of locomotives.
(e) Longitudinal force.

202. Dead Load

The dead load shall consist of the estimated weight of the structural member, plus that of the tracks, ballast and other portions of the structure supported thereby. The weight of materials shall be assumed to be as follows:

Track rails, inside guard rails, and fastenings..	200 pounds per linear foot of track
Ballast, including track ties	120 pounds per cubic foot
Timber	5 pounds per foot board measure
Protective coverings	Actual weight

203. Live Load

The live load per track shall consist of that Cooper loading which will produce a loading effect equivalent to the maximum engine or train load expected to be moved over the completed structure, during its expected life.

On bridges with ballasted deck the live load shall be assumed as distributed laterally over a width equal to the length of track ties, plus twice the depth of ballast below the base of tie, unless deck planks are designed to effect greater distribution of the load.

For members receiving load from more than one track all tracks contributing load shall be assumed fully loaded.

204. Centrifugal Force

On curves, the centrifugal force in percentage of the live load is 0.00117 S^2D. (Because of the limited duration of the loads, centrifugal force need not be considered in the design of stringers).

$S =$ Speed in miles per hour.
$D =$ Degree of curve.

It shall be assumed to act 6 feet above the rail. The table gives the permissible speeds and the corresponding centrifugal force percentages for curves with the amounts of superelevation shown. It is based on a maximum speed of 100 miles per hour and a maximum superelevation of 7 inches, resulting in a maximum centrifugal force of 17.5 percent.

D	E	S	C	D	E	S	C
0°–10′		100	1.95	2°–30′	7	77	17.5
0°–20′		100	3.90	3°– 0′	7	71	17.5
0°–30′	0.33	100	5.85	3°–30′	7	65	17.5
0°–40′	1.44	100	7.80	4°– 0′	7	61	17.5
0°–50′	2.56	100	9.75	5°– 0′	7	55	17.5
1°– 0′	3.67	100	11.7	6°– 0′	7	50	17.5
1°–15′	5.33	100	14.6	8°– 0′	7	43	17.5
1°–30′	7	100	17.5	10°– 0′	7	39	17.5
1°–45′	7	93	17.5	15°– 0′	7	32	17.5
2°– 0′	7	87	17.5	20°– 0′	7	27	17.5
2°–15′	7	82	17.5				

$D =$ Degree of curve.
$E =$ Superelevation in inches.
$S =$ Permissible speed in miles per hour.
$C =$ Centrifugal force in percentage of live load.

$$C = .00117\ S^2D = 1.755\ (E + 3)$$

$$E = \frac{2}{3} \cdot \frac{S^2D}{1000} - 3 = \frac{C - 5.265}{1.755}$$

$$S^2 = \frac{1{,}500}{D}(E + 3)$$

If the conditions at the site restrict the speed to less than that shown in the table, the centrifugal force percentage shall be taken for the greatest speed expected.

The effect of centrifugal force may be reduced by the compensating effect of the actual amount of superelevation provided.

205. Lateral Force

The lateral force due to wind shall be assumed as 30 pounds per square foot of vertical projection of the structure plus any portion of the leeward truss not shielded by the floor system, plus 300 pounds per linear foot of train, applied 8 feet above top of traffic rails. (Because of the limited duration of the load, lateral force need not be considered in the design of stringers).

In computing the stability of towers and trestle bents, the live load on one track shall be 1,200 pounds per linear foot.

206. Nosing of Locomotive

The lateral force due to the nosing of locomotives shall be considered as a single moving force of 20,000 pounds applied at the top of the rail, in either lateral direction, at any point of the span. The resulting vertical forces shall be disregarded. (Because of the limited duration of the loads, the force from the nosing of locomotives need not be considered in the design of stringers).

207. Longitudinal Force

The effect of starting and stopping of trains shall be considered as a longitudinal force, acting 6 feet above top of rail, and taken as the larger of:

(a) Force due to braking, equal to 15 percent of the live load.

(b) Force due to traction, equal to 25 percent of weight on the driving wheels.

For bridges where, by reason of continuity or frictional resistance of rails and floor system, much (or all) of the longitudinal force will be carried directly to the abutments or embankment, longitudinal force need not be considered in the design of piles, posts or bracing of bents. (Such bracing is to be designed to give the necessary L/d stability to the posts).

208. Combined Stresses

For stresses produced by longitudinal force, wind or other lateral forces, or by a combination of these forces with dead and live loads and centrifugal force, the allowable working stresses *other than modulus of elasticity* may be increased 50 percent, provided the resulting sections are not less than those required for dead and live loads and centrifugal force.

III UNIT STRESSES

301. Working Unit Stresses

Working unit stresses to be used for design shall be based on Standard Stress-Grades and Working Stresses, AREA Specifications for Structural Timbers with recommended modifications for "continuously submerged" or "occasionally wet but quickly dried" conditions. These working unit stresses are given in Table 705.

Where timber is treated by creosoting or other process rendering it decay resistant, the working stresses for "continuously dry" may be used.

In locations where serious depreciation is likely to occur, a reduction in working unit stress for extreme fiber and compression should be made, in the judgment of the Engineer.

302. Compression Parallel to Grain

Stress values in Table 705 are to be used for posts and struts where the unsupported length is not greater than 10 times the least dimension, and for end bearing of compression members.

For columns where L/d is over 10, the allowed working stresses are:

$$\frac{P}{A} = C\left[1 - \frac{1}{3}\left(\frac{L}{Kd}\right)^4\right] \text{ for } L/d \text{ less than } K.$$

$$\frac{P}{A} = \frac{0.274\ E}{\left(\frac{L}{d}\right)^2} \text{ for } L/d \text{ greater than } K.$$

$$K = \frac{\pi}{2}\sqrt{\frac{E}{6C}}$$

P = Total load in pounds.
A = Area in square inches.
C = Working stress in compression parallel to the grain. (Table 705)
L = Unsupported length in inches.
d = Least dimension in inches. (See also Section 309).
E = Modulus of elasticity. (Table 705)

Table 706 gives values of allowed $\frac{P}{A}$

Columns should be limited to $\frac{L}{d} = 50$

303. Bearing

The working stresses for compression perpendicular to grain apply to bearings 6 inches or more in length located anywhere in the length of a timber and to bearings of any length at the ends of beams or other members. For bearings shorter than 6 inches located 3 inches or more from the end of a timber the stresses may be increased in accordance with the following factors:

Length of bearing (inches)	½	1	1½	2	3	4	6 or more
Factor	1.85	1.60	1.45	1.30	1.15	1.10	1.00

For stress under a washer the same factor may be taken as for a bearing whose length equals the diameter of the washer.

304. Bearing at Angle to Grain

Allowed bearing stresses on surfaces at an angle to the direction of the grain, may be taken from the following formula:

$$N = \frac{PQ}{P \sin^2\theta + Q \cos^2\theta}$$

Where N = Unit compressive stress in a direction at inclination with the direction of the grain.
P = Unit stress in compression parallel to the grain—Table 705.
Q = Unit stress in compression perpendicular to the grain—Table 705.
θ = Angle between the grain and the normal to the inclined surface.

The chart shown in Fig. 722 gives a graphical solution.

305. Horizontal Shear

The following procedure shall be used for horizontal shear at the neutral plane:

$$S = \frac{3R}{2bh}$$

TABLE 705.—WORKING UNIT STRESSES FOR STRUCTURAL TIMBER

Standard Stress—Grades			Species of Timber	Fiber Stress in Bending or Tension Note A					Maximum Horizontal Shear	Compression Perpendicular to Grain		Compression Parallel to Grain		Modulus of Elasticity
				Continuously Dry	Continuously Submerged		Occasionally Wet but Quickly Dried			Continuously Dry	Continuously Submerged Notes 3, 4 Occasionally Wet but Quickly Dried	Continuously Dry	Occasionally Wet but Quickly Dried	
Joist and Plank Note 1	Beams and Stringers Note 1	Posts and Timbers Note 1		Note 1	Joist and Plank Note 2	Beams and Stringers Note 3	Joist and Plank Note 5	Beams and Stringers Note 5	Note 1 Note 3 Note 5	Note 1	Note 5	Note 1 Continuously Submerged Note 3	Note A Note 5	Note 1 Note 3 Note 5
1800 f.	1800 f.	1300 c.	Douglas Fir, Dense (Coast and Inland)	1800	1590	1800	1390	1575	120	380	266	1300	1195	1, 600, 000
1600 f.	1600 f.	1200 c.	" " Close grained (Coast)	1600	1420	1600	1240	1400	100	345	242	1200	1105	
1200 f.		1100 c.	" " (Coast)	1200	1135		995		100	325	228	1100	1010	
1800 f.	1800 f.	1300 c.	Southern Pine, Dense Longleaf and Shortleaf	1800	1590	1800	1390	1575	120	380	266	1300	1195	1, 600, 000
1600 f.	1600 f.	1200 c.	" " " " " " "	1600	1455	1600	1275	1400	120	380	266	1200	1105	
1400 f.	1400 f.	1000 c.	" " Dense Longleaf	1400	1320	1400	1155	1225	100	380	266	1000	920	
1200 f.	1200 f.	900 c.	" " " Shortleaf	1200	1190	1200	1040	1050	100	380	266	900	825	
1600 f.	1600 f.	1200 c.	Redwood, Close grained	1600	1350	1600	1180	1400	80	267	187	1200	1105	1, 200, 000
1400 f.	1400 f.	1100 c.	" " "	1400	1220	1400	1070	1225	80	267	187	1100	1010	
1200 f.	1200 f.	1000 c.	" " "	1200	1085	1200	950	1050	70	267	187	1000	920	
1400 f.	1400 f.	1200 c.	Cypress, Southern	1400	1220	1400	1070	1225	120	300	210	1200	1105	1, 200, 000
1100 f.	1100 f.	1000 c	" "	1100	1020	1100	890	962	100	300	210	1000	920	
1200 f.		1000 c.	Cedar, Port Orford	1200	1045		915		100	250	175	1000	920	1, 200, 000
1100 f.	1100 f.	900 c.	" " "	1100	980	1100	855	962	80	250	175	900	825	
1000 f.	1000 f.	800 c.	Cedar, Western Red	1000	865	1000	755	875	100	200	140	800	735	1, 000, 000
1100 f.	1100 f.		Hemlock, Eastern	1100	980	1100	855	962	70	300	210			1, 100, 000
1800 f.			Oak, Red and White; Ash, White	1800	1510		1320		120	500	350			1, 600, 000
1600 f.	1600 f.	1100 c.	Oak, Red and White	1600	1380	1600	1210	1400	120	500	350	1100	1010	
1600 f.	1600 f.	1200 c.	Ash, White	1600	1380	1600	1210	1400	120	500	350	1200	1105	
1400 f.	1400 f.	1000 c.	Oak, Red and White; Ash, White	1400	1245	1400	1090	1225	120	500	350	1000	920	
1200 f.	1200 f.		Oak, Red and White; Ash, White	1200	1110	1200	970	1050	100	500	350			
1800 f.			Beech; Birch; Hard Maple; Rock Elm	1800	1535		1340		120	500	350			1, 600, 000
1600 f.	1600 f.	1300 c.	" " " " " "	1600	1400	1600	1225	1400	120	500	350	1300	1195	except
1400 f.	1400 f.	1200 c.	" " " " " "	1400	1265	1400	1105	1225	120	500	350	1200	1105	1, 300, 000
1200 f.	1200 f.	1000 c.	" " " " " "	1200	1135	1200	995	1050	100	500	350	1000	920	for Rock Elm
1400 f.			Elm, Soft	1400	1175		1030		100	250	175			1, 200, 000
1200 f.	1200 f.	900 c.	" "	1200	1045	1200	915	1050	100	250	175	900	825	
1000 f.	1000 f.		" "	1000	910	1000	795	875	100	250	175			
1400 f.			Gum, Black and Red; Tupelo	1400	1175		1030		100	300	210			1, 200, 000
1200 f.	1200 f.	900 c.	" " " " "	1200	1045	1200	915	1050	100	300	210	900	825	
1000 f.	1000 f.		" " " " "	1000	910	1000	795	875	100	300	210			
1200 f.			Chestnut	1200	1010		885		100	300	210			1, 000, 000
1000 f.	1000 f.	900 c.	"	1000	880	1000	770	875	100	300	210	900	825	

Note 1 Stress-grades represent safe working unit stresses applicable to material used in locations continuously dry or covered.

Note 2 Stresses for joist and plank assume strength increased by seasoning; hence extreme fiber stress is reduced where not continuously dry.

Note 3 For timber continuously submerged, no reduction in working stress, except that compression perpendicular to grain is reduced to 70 per cent of dry bearing value.

Note 4 For joist and plank continuously submerged, use basic unit stress without increase due to seasoning, except compression perpendicular to grain reduced to 70 per cent.

Note 5 For locations occasionally wet but quickly dried, use following percentages of stress-grade values: Fiber stress 87.5 per cent, compression perpendicular to grain 70 per cent, compression parallel to grain 92 per cent, horizontal shear 100 per cent, modulus of elasticity 100 per cent. For joist and plank apply to values without seasoning.

Note A: In locations of more extreme exposure, and where serious depreciation may occur, make further reduction in allowed fiber stress and compression.

TABLE 706.—UNIT COMPRESSION (COLUMN) STRESSES FOR STANDARD STRESS GRADES

Short Column Stress	*Modulus of Elasticity*	*K*	*Stress at Ratio of Length to Least Dimension (L/d)*											
			10	*12*	*14*	*16*	*18*	*20*	*25*	*30*	*35*	*40*	*45*	*50*
1300	1,300,000	20.3	1300	1247	1203	1132	1032	892	570	396	291	223	176	142
	1,600,000	22.5	1300	1265	1235	1190	1123	1030	701	487	358	274	216	175
1200	1,200,000	20.3	1200	1151	1110	1045	953	823	526	365	268	206	162	132
	1,300,000	21.1	1200	1158	1122	1068	989	827	570	396	291	223	176	142
	1,500,000	22.7	1200	1169	1142	1102	1042	959	658	457	336	257	203	164
	1,600,000	23.4	1200	1172	1148	1112	1060	986	701	487	358	274	216	175
1100	1,200,000	21.2	1100	1063	1031	981	910	810	526	365	268	206	162	132
	1,300,000	22.1	1100	1068	1041	999	938	854	570	396	291	223	176	142
	1,500,000	23.7	1100	1076	1055	1024	978	914	658	457	336	257	203	164
	1,600,000	24.4	1100	1078	1060	1032	991	935	701	487	358	274	216	175
1000	1,200,000	22.2	1000	972	947	910	856	780	526	365	268	206	162	132
	1,300,000	23.1	1000	976	955	923	877	813	570	396	291	223	176	142
	1,500,000	24.8	1000	982	966	942	908	859	658	457	336	257	203	164
	1,600,000	25.6	1000	984	970	948	918	876	697	487	358	274	216	175
900	1,000,000	21.4	900	870	845	806	750	674	438	304	224	171	135	110
	1,200,000	23.4	900	879	861	834	795	740	526	365	268	206	162	132
	1,600,000	27.0	900	888	878	863	841	810	680	487	358	274	216	175
800	1,000,000	22.7	800	779	762	734	694	639	438	304	224	171	135	110

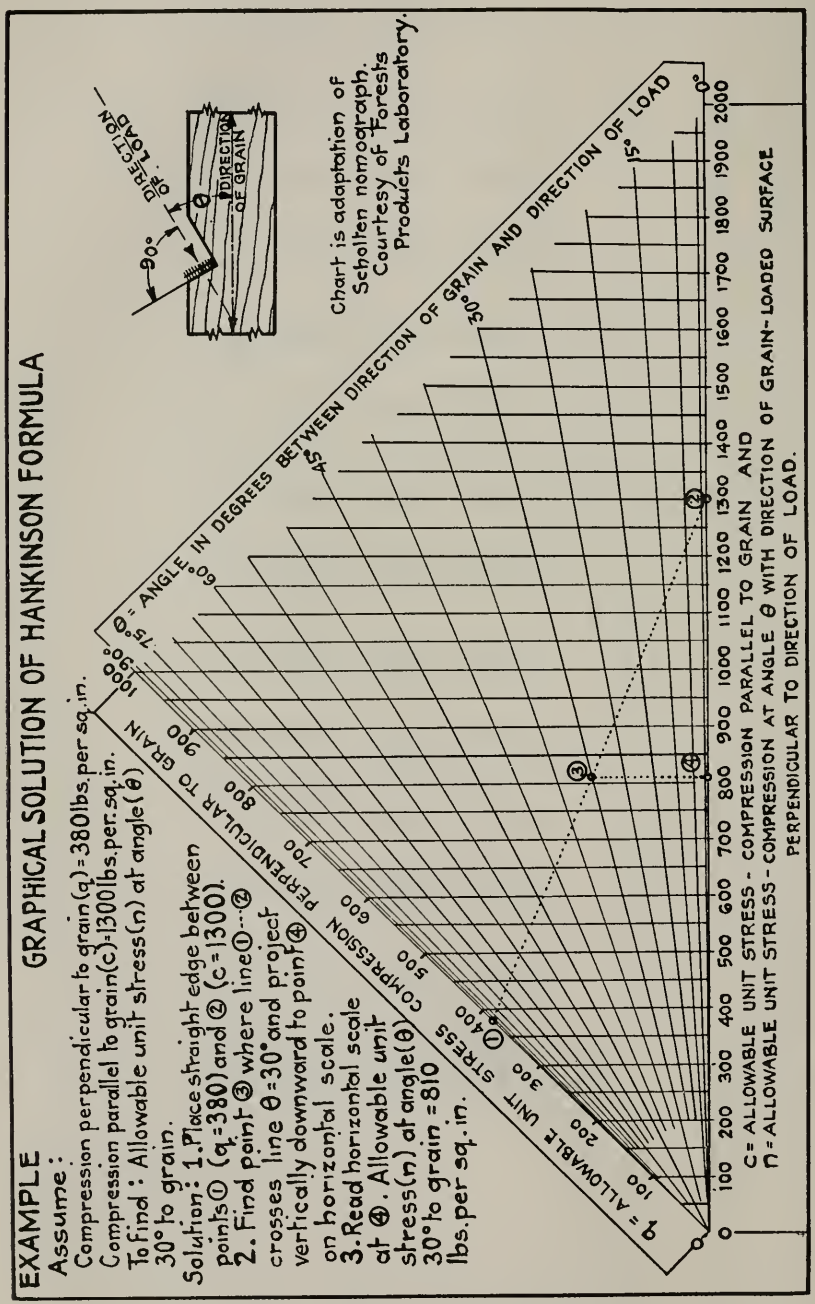

EXAMPLE
Assume:
Compression perpendicular to grain (q) = 380 lbs. per sq. in.
Compression parallel to grain (c) = 1300 lbs. per sq. in.
To Find: Allowable unit stress (n) at angle (θ) 30° to grain.
Solution: 1. Place straight edge between points ① (q = 380) and ② (c = 1300).
2. Find point ③ where line ①···② crosses line θ = 30° and project vertically downward to point ④ on horizontal scale.
3. Read horizontal scale at ④. Allowable unit stress (n) at angle (θ) 30° to grain = 810 lbs. per sq. in.
GRAPHICAL SOLUTION OF HANKINSON FORMULA
θ = ANGLE IN DEGREES BETWEEN DIRECTION OF GRAIN AND DIRECTION OF LOAD
PERPENDICULAR TO GRAIN
COMPRESSION
UNIT STRESS
ALLOWABLE
q =
C = ALLOWABLE UNIT STRESS - COMPRESSION PARALLEL TO GRAIN AND
n = ALLOWABLE UNIT STRESS - COMPRESSION AT ANGLE θ WITH DIRECTION OF GRAIN-LOADED SURFACE PERPENDICULAR TO DIRECTION OF LOAD.
Chart is adaptation of Scholten nomograph. Courtesy of Forests Products Laboratory.
DIRECTION OF LOAD
DIRECTION OF GRAIN
90°
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
0° 15° 30° 45° 60° 75° 90°

Fig. 722.

in which $S =$ Maximum unit shear per square inch.
$R =$ Reaction in pounds.
$b =$ Breadth of beam in inches.
$h =$ Height of beam in inches.

The results obtained must not exceed the allowable unit shear stress.

(a) In calculating the reaction for use in the formula:

(1) Take into account any relief to the beam under consideration resulting from the loading being distributed to adjacent parallel beams by flooring or other members of the construction.

(2) Neglect all loads within the height of the beam from both supports.

(3) If there are any moving loads, place the largest one at 3 times the height of the beam from the support.

(4) Treat all other loads in the usual manner.

(b) If a timber does not qualify under the above recommendations, which under certain conditions may be over-conservative, the reactions for the concentrated loads should be determined by the following equation:

$$r = \frac{10P(L - a)\left(\frac{a}{h}\right)^2}{9L\left[2 + \left(\frac{a}{h}\right)^2\right]}$$

in which $r =$ Reaction to be used as due to load P.
$L =$ Span in inches.
$a =$ Distance in inches from reaction to load P.
$h =$ Height of beam in inches.

306. Shearing Stress

The allowable shearing stress for joint details shall be taken at 50 percent greater than the values for horizontal shear in Table 705.

307. Bearing on Bolts

Working unit stresses for timber bearing on bolts may be taken as the *product* of the following factors:

(1) Basic unit stress for bearing, Table 707.

(2) Factor based on L/d ratio of bolt, Table 708.

(3) For bearing perpendicular to the grain only, a factor as follows:

Diameter of bolt, inches	⅜	½	⅝	¾	⅞	1	1¼	1½	1¾	2	2½	3
Diameter factor	1.95	1.68	1.52	1.41	1.33	1.27	1.19	1.14	1.10	1.07	1.03	1

Bolts acting at an angle with the grain shall be allowed bearing values by the formula in Section 304, where P and Q are allowed bearing values computed for the L/d ratio of the bolt.

308. Connectors

Where metal connectors are used, working values may be taken as those recommended or approved by the Forest Products Laboratory.

309. Round Sections

The strength, stiffness, and horizontal shearing value in bending of round timbers of any species may be assumed to be identical with that of square timbers of the same grade and cross-sectional area. Tapered timbers should be assumed as of uniform

TABLE 707.—BASIC UNIT STRESSES FOR BEARING ON BOLTS

Group	Species of Wood	Basic Unit Stress: Parallel with Grain	Basic Unit Stress: Perpendicular to Grain
	Softwoods (conifers)		
1	Hemlock, Eastern	800	150
2	Cedar, Port Orford and Western Red; Douglas Fir, Inland	1000	200
3	Cypress, Southern; Douglas Fir, Coast; Pine, Southern; Redwood	1300	275
	Hardwoods (broad leaved)		
1	Chestnut	925	175
2	Elm, soft; Gum, Black and Red; Tupelo	1200	250
3	Ash, white; Beech; Birch; Elm, Rock; Maple, hard; Oak, red, white	1500	400

Above values are for continuously dry location.
For occasionally wet but quickly dried use ¾ of values in table.
For damp or wet most of the time, use ⅔ of values in table.

TABLE 708.—PERCENTAGE OF BASIC STRESS FOR VARIOUS L/d VALUES

Length L / Diameter d Ratio	Parallel with Grain: Common Bolts Group 1	Parallel with Grain: Common Bolts Group 2	Parallel with Grain: Common Bolts Group 3	Parallel with Grain: High Strength Bolts Group 1	Parallel with Grain: High Strength Bolts Group 2	Parallel with Grain: High Strength Bolts Group 3	Perpendicular to Grain: Common Bolts Group 1	Perpendicular to Grain: Common Bolts Conifers Group 2	Perpendicular to Grain: Common Bolts Conifers Group 3 Hardwoods Group 2	Perpendicular to Grain: Common Bolts Hardwoods Group 3	Perpendicular to Grain: High Strength Bolts All Groups
1 to 2	100	100	100	100	100	100	100	100	100	100	100
3	100	100	99.0	100	100	100	100	100	100	100	100
4	99.5	97.4	92.5	100	100	99.0	100	100	100	100	100
5	95.4	88.3	80.0	100	99.8	96.0	100	100	100	100	100
6	85.6	75.8	67.2	100	95.4	89.5	100	100	100	96.3	100
7	73.4	65.0	57.6	95.8	88.8	81.0	100	100	97.3	86.9	100
8	64.2	56.9	50.4	89.3	81.2	73.0	100	96.1	88.1	75.0	100
9	57.1	50.6	44.8	82.5	74.2	66.4	94.6	86.3	76.7	64.6	97.7
10	51.4	45.5	40.3	75.8	68.0	60.2	85.0	76.2	67.2	55.4	90.0
11	46.7	41.4	36.6	69.7	61.9	54.8	76.1	67.6	59.3	48.4	81.5
12	42.8	37.9	33.6	64.0	56.7	50.2	68.6	61.0	52.0	42.5	73.6
13	39.5	35.0	31.0	59.1	52.4	46.3	62.2	55.3	45.9	37.5	66.9

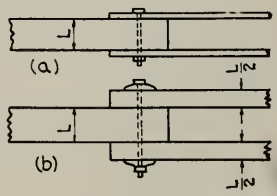
Above values are for joints with metal plates. (Fig. a) Where wood splice plates are used, each one-half of thickness of main timber, (Fig. b) use 80 percent of tabular value for bearing parallel with grain; no reduction for bearing perpendicular to grain.

Common bolts: yield point about 45,000 pounds per square inch.

High strength bolts: yield point about 125,000 pounds per square inch.

L = length of bolt in main timber in inches.

d = diameter of bolt in inches.



diameter, the point of measurement being ⅓ the span from the small end, but the diameter should not be assumed to be more than 1½ times the small end diameter.

The strength of round columns may be considered the same as that of square columns of the same cross-sectional area. In long tapered columns the strength may be assumed as identical with that of a square column of the same length, and of cross-sectional area equal to that of the round timber measured at a point one-third its length from the small end. The stress at the small end must not exceed the allowable stress for short columns.

IV DETAILS OF DESIGN

401. General

All members shall be framed, anchored, tied and braced to develop the strength and rigidity necessary for the purposes intended.

402. Net Section

All stress computations shall be based on actual size of timbers. Where members are dapped or otherwise framed to materially reduce the effective size, the net section of the piece shall be used.

403. Bolted Connections

The center-to-center distance along the grain between bolts acting parallel with the grain shall be not less than 4 times the bolt diameter.

The tension area remaining at the critical section should be at least 80 percent of the total area in bearing under all bolts for coniferous woods; 100 percent for hardwoods.

In a tension joint, the distance from the end of the timber to the center of nearest bolt shall be not less than 7 times the bolt diameter for coniferous woods; 5 times for hardwoods. For compression stress, this end distance need be only 4 times the bolt diameter.

For loads acting perpendicular to the grain, the distance between the edge toward which the bolt pressure is acting, and the center of the bolt nearest this edge, should be not less than 4 times the bolt diameter.

404. Notched Beams

The allowable end reaction for beams with square-cornered notches at the ends shall be computed by the following formula:

$$V = \frac{2}{3}\frac{bc^2q}{d}$$

$b =$ Width.
$c =$ Depth above the notch.
$d =$ Total depth of beam.
$q =$ Working unit stress in horizontal shear.
$V =$ Allowable end reaction.

Report of Committee 8—Masonry

J. F. Leonard, *Chairman,*
G. E. Boyd
H. E. Burr
F. W. Capp
Maurice Coburn
T. L. Condron
G. H. Dayett
Theodore Doll
G. F. Eberly
R. Hayes
Meyer Hirschthal
A. C. Irwin
M. L. Johnson
J. E. Kalinka
W. A. Kingman
J. A. Lahmer
C. P. Marsh
R. L. Mays
L. M. Morris
Roscoe Owen
O. V. Parsons*
I. L. Pyle
W. M. Ray
J. L. Rippey
F. B. Robins
G. E. Robinson
C. P. Schantz
G. E. Shaw
A. N. Laird, *Vice-Chairman,*
G. R. Smiley**
F. R. Smith
C. H. Splitstone
L. I. Stone
E. O. Sweetser
Jamison Vawter
H. J. Voelker
L. W. Walter
C. A. Whipple
W. R. Wilson
J. J. Yates
Committee

* Died, December 10, 1941; ** Died, June 10, 1941.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, including new Specifications for Portland Cement and methods of test with the recommendation that they be adopted for publication to replace corresponding material now in the Manual ..... page 258

2. Specifications and principles of design of plain and reinforced concrete for use in railway bridges, buildings and culverts, collaborating with Committees 1—Roadway and Ballast, 5—Track, 6—Buildings, 7—Wood Bridges and Trestles, 13—Water Service, Fire Protection and Sanitation, and 15—Iron and Steel Structures.

   (a) Reinforced concrete box culverts.

   No report.

   (b) Concrete bridge deck slabs of the non-ballast type, collaborating with Committee 5—Track.

   Progress report, presented as information ..... page 316

3. Progress in the science and art of concrete manufacture.

   Progress report, presented as information ..... page 317

4. Maintain contact with Joint Committee on Concrete and Reinforced Concrete.

   No report.

5. Specifications for foundations, including excavation, cofferdam, piling, etc., collaborating with Committee 1—Roadway and Ballast on soil mechanics, and with Committee 7—Wood Bridges and Trestles on bearing power of wood piles and pile driving.

   Progress report in the form of a bibliography, presented as information ... page 318

6. Methods and practices of lining and relining tunnels, collaborating with Committee 1 —Roadway and Ballast.

   Progress report, embracing recommended additions to the Manual ..... page 330

7. Review specifications for overhead highway bridges of the American Association of State Highway Officials, insofar as they relate to masonry, conferring with that association and Committee 15—Iron and Steel Structures.

   No report.

8. Progress in cement manufacture and testing.

   Report on this assignment presented under Assignment 3 ..... page 317

9. Bibliography and review of current engineering literature pertaining to railroad masonry work.

   No report.

10. Pressure grouting.

    Progress report, including matter recommended for adoption and publication in the Manual ..... page 336

11. Specifications for concrete and reinforced concrete railroad bridges and other structures.

    Progress report, including new specifications, presented as information .... page 337

12. Specifications for test borings, collaborating with Committee 1—Roadway and Ballast.

    Final report, including specifications recommended for adoption and publication in the Manual ..... page 355

THE COMMITTEE ON MASONRY,
J. F. LEONARD, *Chairman.*

Report on Assignment 1

Revision of Manual

G. E. Boyd (chairman, subcommittee), T. L. Condron, Meyer Hirschthal, J. A. Lahmer, I. L. Pyle, C. P. Schantz, G. E. Shaw, F. R. Smith, C. A. Whipple.

The committee recommends the following revisions of the Manual:

Change the references to the ASTM Specifications for Reinforced Concrete Culvert Pipe which appear on Manual page 8–90 from C 76–37 to C 76–40 T.

Withdraw all matter relating to Specifications for High Early Strength Portland Cement, Portland Cement and Methods of Sampling and Testing Portland Cement, pp. 8–5 to 8–20.4 inclusive, and substitute the following:

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT

1942

The same as ASTM Designation C 150–41

Scope

1. These specifications cover five types of Portland cement, as follows:

Type I.—For use in general concrete construction when the special properties specified for types II, III, IV, and V are not required.

Type II.—For use in general concrete construction exposed to moderate sulfate action, or where moderate heat of hydration is required.

Type III.—For use when high early strength is required.

Type IV.—For use when a low heat of hydration is required (Note.)

Type V.—For use when high sulfate resistance is required (Note).

NOTE.—Attention is called to the fact that cements conforming to the requirements for type IV and type V are not usually carried in stock. In advance of specifying their use, purchasers or their representatives should determine whether these types of cement are, or can be made available.

Basis of Purchase

2. The purchaser should specify the type or types desired. When no type is specified, the requirements of type I shall govern.

Definition

3. *Portland Cement.*—Portland cement is the product obtained by pulverizing clinker consisting essentially of hydraulic calcium silicates, to which no additions have been made subsequent to calcination other than water and/or untreated calcium sulfate, except that other materials may be added provided that they have been shown to be acceptable, in the amounts indicated, by tests carried out or reviewed by Committee C–1.*

NOTE.—Tests to determine whether a proposed addition is acceptable will be carried out or reviewed by Committee C–1 on Cement, for those making requests. In the year following that in which an addition has been declared acceptable by the committee, the name of the addition and the amount permitted shall appear as an addendum to Section 3 in a revision of the specifications.

Chemical Limits

4. Portland cement of each of the five types shown in Section 1 shall conform to the requirements prescribed in Table I.

Physical Requirements

5. Portland cement of each of the five types shown in Section 1 shall conform to the requirements prescribed in Table II.

Packaging and Marking

6. When cement is delivered in packages, the name and brand of the manufacturer shall be plainly marked thereon. The type and ASTM specification number C 150, and the amount and kind of any acceptable interground addition that may be present shall

* The committee has declared as acceptable the inclusion of the material known commercially as TDA (composed of triethanolamine and highly purified soluble calcium salts of modified lignin sulfonic acids), manufactured by the Dewey and Almy Chemical Co., when added in an amount not exceeding 0.043 percent by weight of the cement, except that in Type III cement a maximum of 0.08 percent by weight may be used.

be clearly stated in the shipping advices accompanying the shipment of packaged or bulk cement. A bag shall contain 94 lb. net. A barrel shall consist of 376 lb. net. All packages shall be in good condition at the time of inspection.

Storage

7. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weathertight building that will protect the cement from dampness and minimize warehouse set.

TABLE I.—CHEMICAL REQUIREMENTS

	Type I	*Type II*	*Type III*	*Type IV*[a]	*Type V*[a]
Silicon dioxide (SiO_2), min., per cent	----	21.0	----	----	24.0
Aluminum oxide (Al_2O_3), max., per cent	----	6.0	----	----	4.0
Ferric oxide (Fe_2O_3), max., per cent	----	6.0	----	6.5	4.0
Magnesium oxide (MgO), max., per cent	5.0	5.0	5.0	5.0	4.0
Sulfur trioxide (SO_3), max., per cent	2.0	2.0	2.5	2.0	2.0
Loss on ignition, max., per cent	3.0	3.0	3.0	2.3	3.0
Insoluble residue, max., per cent	0.75	0.75	0.75	0.75	0.75
Ratio of AL_2O_3 to Fe_2O_3	----	0.7 to 2.0	----	----	0.7 to 2.0
Tricalcium silicate ($3CaO.SiO_2$),[b] max., per cent	----	50	----	35	----
Dicalcium silicate ($2CaO.SiO_2$),[b] min., per cent	----	----	----	40	----
Tricalcium aluminate ($3CaO.Al_2O_3$),[b] max., per cent	----	8	15	7	5

[a] See Note, Section 1.

[b] The expressing of chemical limitations by means of calculated assumed compounds does not necessarily mean that the oxides are actually or entirely present as such compounds.

The percentages of tricalcium silicate, dicalcium silicate, and tricalcium aluminate shall be calculated from the chemical analysis as follows:

Tricalcium silicate =
$(4.07 \times \text{per cent CaO}) - (7.60 \times \text{per cent } SiO_2)$
$- (6.72 \times \text{per cent } Al_2O_3) - (1.43 \times \text{per cent } Fe_2O_3) - (2.85 \times \text{per cent } SO_3)$

Dicalcium silicate =
$(2.87 \times \text{per cent } SiO_2) - (0.754 \times \text{per cent } 3CaO.SiO_2)$

Tricalcium aluminate =
$(2.65 \times \text{per cent } Al_2O_3) - (1.69 \times \text{per cent } Fe_2O_3)$

Oxide determinations calculated to the nearest 0.1 per cent shall be used in the calculations. Compound percentages shall be calculated to the nearest 0.1 per cent and reported to the nearest 1 per cent.

Inspection

8. Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. The following periods from time of sampling shall be allowed for completion of testing:

1-day test	6 days
3-day test	8 days
7-day test	12 days
28-day test	33 days

Rejection

9. *(a)* The cement may be rejected if it fails to meet any of the requirements of these specifications.

(b) Cement remaining in bulk storage at the mill, prior to shipment, for a period greater than 6 months after completion of the tests may be retested and may be rejected if it fails to conform to any of the requirements of these specifications.

(c) Packages varying more than 5 percent from the specified weight may be rejected; and if the average weight of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that specified, the entire shipment may be rejected.

TABLE II.—PHYSICAL REQUIREMENTS

	Type I	*Type II*	*Type III*	*Type IV*[a]	*Type V*[a]
Fineness, specific surface, sq. cm. per g.:					
Average value, min.	1600	1700	----	1800	1800
Minimum value, any one sample	1500	1600	----	1700	1700
Soundness:					
Autoclave expansion, max., per cent	0.50	0.50	0.50	0.50	0.50
Time of setting (alternate methods):[b]					
Gillmore test:					
Initial set, min., not less than	60	60	60	60	60
Final set, hr., not more than	10	10	10	10	10
Vicat test:					
Initial set, min., not less than	45	45	45	45	45
Final set, hr., not more than	10	10	10	10	10
Tensile strength, psi.:[c] The average tensile strength of not less than three standard mortar briquets, prepared in accordance with Methods C 77, shall be equal to or higher than the values specified for the ages indicated below:					
1 day in moist air	----	----	275	----	----
1 day in moist air, 2 days in water	150	125	375	----	----
1 day in moist air, 6 days in water	275	250	----	175	175
1 day in moist air, 27 days in water	350	325	[c]	300	300
Compressive strength, psi.:[c] The average compressive strength of not less than three mortar cubes, prepared in accordance with Method C 109, shall be equal to or higher than the values specified for the ages indicated below:					
1 day in moist air	----	----	1300	----	----
1 day in moist air, 2 days in water	1000	750	3000	----	----
1 day in moist air, 6 days in water	2000	1500	----	800	1000
1 day in moist air, 27 days in water	3000	3000	[c]	2000	2200

[a] See Note, Section 1.

[b] The purchaser should specify the type of setting time test required. In case he does not so specify, the requirement of the Gillmore test only shall govern.

[c] The purchaser should specify the type of strength test required. In case he does not so specify, the requirements of the tensile strength test only shall govern. The strength at any age shall be higher than the strength at the next preceding age. Tests at 28 days on types I and II cement may be waived at the option of the purchaser. If, at the option of the purchaser, a 28-day test is required on type III cement, the strength at 28 days shall be higher than at 3 days.

Methods of Testing

10. The cement shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the following methods of the ASTM:

(a) Chemical Analysis.—Standard Methods of Chemical Analysis of Portland Cement (ASTM Designation: C 114–40) and Tentative Methods of Chemical Analysis of Portland Cement (ASTM Designation: C 114–40 T).

(b) Sampling and Physical Tests.—Standard Methods of Sampling and Physical Testing of Portland Cement (ASTM Designation: C 77).

(c) Compressive Strength.—Tentative Method of Test for Compressive Strength of Portland-Cement Mortars (ASTM Designation: C 109), when specified.

(d) Fineness.—Tentative Method of Test for Fineness of Portland Cement by Means of the Turbidimeter (ASTM Designation: C 115).

(e) Autoclave Expansion.—Tentative Method of Test for Autoclave Expansion of Portland Cement (ASTM Designation: C 151).

STANDARD METHODS OF CHEMICAL ANALYSIS OF PORTLAND CEMENT

1942

The same as ASTM Designation: C 114–40

Scope

1. These methods outline procedures for the chemical analysis of Portland cement. The procedures appear in the following order:

	Section
Blank Determinations	5
Silicon Dioxide	6
Aluminum Oxide and Ferric Oxide	7
Aluminum Oxide	8
Ferric Oxide	9 and 10
Calcium Oxide	11
Magnesium Oxide:	
Referee Method	12 and 13
Rapid Determination by Acid–Alkali Method	14 and 15
Rapid Determination by Titration of Magnesium Oxyquinolate	16 and 17
Sulfur Trioxide	18
Loss on Ignition	19
Sodium Oxide and Potassium Oxide	20 and 21
Water-Soluble Alkali	22
Phosphorus Pentoxide:	
Method A	23 and 24
Method B, Alternate Procedure	25 and 26
Manganic Oxide:	
Method A	27 and 28
Method B, Alternate Procedure	29 and 30
Insoluble Residue	31
Chloroform-Soluble Organic Substances	32 and 33
Recommended Order for Reporting Analysis	34

Sampling

2. Samples of the cement shall be taken and prepared as prescribed in Sections 2 to 5 of the Standard Methods for Sampling and Physical Testing of Portland Cement (ASTM Designation: C 77) of the ASTM.

Apparatus

3. *(a) Balances.*—The balances used in the chemical determinations shall conform to the following requirements:

Capacity not less than 100 g. in each pan,

The two arms of the beam equal within one part in 100,000,

Capable of reproducing results within 0.1 mg., and

"Sensibility reciprocal"* at loads of 100 g. or less, not more than 0.2 mg. per division of the graduated scale.

(b) Weights.—The weights used in the chemical determinations shall conform to the requirements of the National Bureau of Standards specifications for class "S" weights as contained in Bureau of Standards *Circular No. 3.*

* The sensibility reciprocal is a measure of the sensitiveness of a balance, and is the weight required to move the position of equilibrium of the pointer one division. For a complete definition of sensibility reciprocal, see National Bureau of Standards *Handbook,* H–22, pp. 68–69.

Number of Chemical Determinations

4. *(a)* The number of chemical tests shall be as prescribed in Section 5 of the Standard Methods of Sampling and Physical Testing of Portland Cement (ASTM Designation: C 77) of the ASTM.

(b) The chemical determinations shall be made in accordance with the procedures described in the following Sections 6 to 33.

NOTE.—These methods of chemical analysis are not considered as possessing the highest obtainable accuracy, but are methods to be followed in making acceptance tests on cements covered by specifications requiring that tests be made in accordance with the analytical procedures contained in this standard.

Blank Determinations

5. Blank determinations shall be made on approximately the same amount of reagents and using the procedures described in Sections 6, 7, 11, 13, 15, 17, 18, 21, 22, 24, 26, 28, and 30. The results obtained in the analysis shall be corrected accordingly.

SILICON DIOXIDE

Procedure

6. *(a)* Transfer 0.5 g. of the finely powdered sample to an evaporating dish, preferably of platinum for the sake of celerity in evaporation, moisten with 10 ml. of cold water to prevent lumping, add 5 to 10 ml. of HCl (sp. gr. 1.19), and digest with the aid of gentle heat and agitation until solution is complete. Solution may be aided by light pressure with the flattened end of a glass rod. Evaporate the solution to dryness on a steam bath. Without heating the residue any further, treat it with 5 to 10 ml. of HCl (sp. gr. 1.19) and then an equal amount of water, or pour at once upon the residue 10 to 20 ml. of diluted HCl (1:1). Then cover the dish and digest for 10 min. on the bath or a hot plate. Dilute the solution with an equal volume of hot water, immediately filter, and wash the separated silicon dioxide (SiO_2) thoroughly with hot water, and reserve. Again evaporate the filtrate to dryness, baking the residue in an oven for 1 hr. at 105 to 110 C. Then take up the residue with 10 to 15 ml. of diluted HCl (1:1) and heat on the bath or hot plate. Dilute the solution with an equal volume of hot water and catch and wash the small amount of SiO_2 it contains on another filter paper. Reserve the filtrate and washings. Transfer this paper and the reserved paper containing the residues to a weighed platinum crucible. Dry and ignite the papers, first at a low heat until the carbon of the filter paper is completely consumed without inflaming, and finally at 1,100 to 1,200 C. until the weight remains constant.

(b) Treat the SiO_2 thus obtained, which will contain small amounts of impurities, in the crucible with a few drops of water, about 10 ml. of HF, and one drop of H_2SO_4, and evaporate cautiously to dryness. Finally, heat the small residue at 1,050 to 1,100 C. for a minute or two, cool, and weigh. The difference between this weight and the weight previously obtained represents the amount of SiO_2. Washing of the SiO_2 precipitates can be made more effective by using a hot solution of diluted HCl (1:99) and then completing the washing with hot water. Consider the weighed residue remaining after volatilization of the SiO_2 as combined aluminum and ferric oxides and add it to the result obtained in the determination of these oxides (Section 7).

Aluminum Oxide and Ferric Oxide

Procedure

7. Treat the reserved filtrate (Note 1), which should have a volume of about 250 ml., with HCl if necessary to insure a total of 10 to 15 ml. of the acid, add a few drops of methyl red indicator (0.2 percent in ethanol), and then heat to boiling. Then treat with NH_4OH (Note 2), drop by drop, until one drop changes the color of the solution to a distinct yellow. Bring to boiling the solution containing the precipitated aluminum and ferric hydroxides, boil for 1 or 2 min., and then filter. Wash the precipitate once by decantation and wash slightly on the filter with a hot NH_4NO_3 solution (2 percent). Set aside the filtrate and transfer the precipitate and filter paper to the same beaker in which the first precipitation was effected. Then dissolve the aluminum and ferric hydroxides in hot diluted HCl (1:3), make up the solution to about 100 ml., and reprecipitate the hydroxides as in the first case. Then filter the solution, and wash the precipitate with two 10-ml. portions of a hot NH_4NO_3 solution (2 percent). Combine the filtrate and washings with the filtrate set aside, place the precipitate in a weighed platinum crucible, heat slowly until the papers are charred, and finally ignite to constant weight at 1,050 to 1,100 C. with care to prevent reduction, and weigh as $Al_2O_3 + Fe_2O_3$.

Note 1.—If a platinum evaporating dish has been used for the dehydration of SiO_2, iron may have been partially reduced. At this stage, add about 3 ml. of saturated aqueous solution of bromine to the filtrate and boil the filtrate to eliminate the excess bromine before adding the methyl red indicator.

Note 2.—The NH_4OH used to precipitate the hydroxides must be free of contamination with CO_2.

Aluminum Oxide

Procedure

8. Determine the content of aluminum oxide by deducting the content of ferric oxide determined according to Section 9 from the content of aluminum oxide and ferric oxide determined according to Section 7.

Note.—Any titanium and phosphorus that may be present will be precipitated with aluminum and ferric hydroxides in the procedure specified in Section 7 and are counted as Al_2O_3. Aluminum oxide should not be corrected for TiO_2 or P_2O_5 unless such a correction is expressly specified. If the precipitations of the hydroxides are made as directed, little manganese, if any, will be retained in the precipitate.

Ferric Oxide

Special Solutions Required

9. *(a) Stannous Chloride Solution.*—Dissolve 2 g. of $SnCl_2.2H_2O$ in ten times its weight of a mixture of three parts of water and one of HCl (sp. gr. 1.19). Add scraps of iron-free granulated tin and boil until the solution is clear. Keep the solution in a closed dropping bottle containing metallic tin.

(b) Phosphoric-Sulfuric Acid Mixture.—Add slowly, while stirring, 150 ml. of H_3PO_4 (sp. gr. 1.71) and 150 ml. of H_2SO_4 (sp. gr. 1.84) to 500 ml. of water, and then dilute to 1,000 ml. with water and mix.

(c) Diphenylamine Indicator.—Dissolve 1 g. of diphenylamine in 100 ml. of H_2SO_4 (sp. gr. 1.84).

(d) Standard Potassium Dichromate Solution.—Dissolve 2.457 g. of $K_2Cr_2O_7$ in distilled water and dilute to 1 liter. Standardize against standard iron wire of known iron content in the same manner as directed for the ferric oxide determination in cement (Section 10), using a weight of iron wire which will yield a titration approximately equal to that required by the cement sample in question.

Procedure

10. To 1 g. of the sample add 40 ml. of cold water, stir, and add 15 ml. of HCl (sp. gr. 1.19). Heat the solution and grind the cement with the flattened end of a glass rod until it is evident that the cement is completely decomposed. Heat the solution to boiling and treat it with the $SnCl_2$ solution, added drop by drop while stirring until the solution is decolorized. Add one drop in excess and cool the solution to room temperature. Rinse the inside of the vessel with water, and add all at once 10 ml. of a cool, saturated $HgCl_2$ solution. Stir the solution vigorously for 1 min., treat with 15 ml. of H_3PO_4–H_2SO_4 mixture and 3 drops of diphenylamine indicator, and dilute to 150 ml. with cold water. Titrate with a standard $K_2Cr_2O_7$ solution having a titer not greater than 0.004 g. of Fe_2O_3 per ml. The end point is taken as the point at which a drop causes an intense deep blue coloration that remains unchanged on the further addition of the standard $K_2Cr_2O_7$ solution.

Calcium Oxide

Procedure

11. Add a few drops of NH_4OH to the combined filtrates obtained in the precipitations of aluminum and ferric hydroxides (Section 7) and bring the solution to boiling. Add to the boiling solution 25 ml. of a boiling $(NH_4)_2C_2O_4$ solution (5 percent), the boiling being continued until the precipitated CaC_2O_4 assumes a well-defined granular form. Then allow the solution to stand for about 20 min. or until the precipitate has settled, filter, and wash moderately with $(NH_4)_2C_2O_4$ (0.1 percent). Reserve the filtrate and washings. Place the filter paper containing the precipitate, wet, in a platinum crucible and burn off the paper at a low heat. Then ignite the precipitate until the CaC_2O_4 is converted to CaO (Note), redissolve in HCl, and dilute the solution to 100 ml. with water. Add NH_4OH in slight excess and bring the solution to boiling. If a small amount of hydroxides separates at this point, filter it out, weigh, and add the amount to that found in the original determination of Al_2O_3 and Fe_2O_3. Then reprecipitate the CaO by $(NH_4)_2C_2O_4$, allow to stand until settled, filter, and wash, taking care to avoid an excess of the washing solution. Combine the filtrate with that already reserved. Weigh the precipitate as CaO, after ignition and heating at 1,100 to 1,200 C. to constant weight in a weighed, covered platinum crucible.

Note.—If the ignited precipitate is darkly colored, it may contain an appreciable amount of manganese. The contamination of the second precipitate of calcium oxalate by manganese should be as low as possible. The following procedure may be used to reduce the contamination: add 5 ml. of cold water cautiously to the first precipitate and then cautiously add 10 ml. of diluted HCl (1:1). Heat the mixture. If the resulting solution is colored, digest it gently on the hot plate for 10 min. or longer until the color disappears, or until it is apparent the color will not become lighter on further heating. After a little practice it is possible to dissolve hard-burnt lime in this way without explosive spattering.

If the second precipitate of CaC_2O_4 is so fine as to cause difficulty in filtering, or if the precipitate causes bumping, the volume of solution may be increased to 150 or 200 ml., instead of 100 ml., prior to precipitation.

Magnesium Oxide

Referee Method

In this method for determining magnesium oxide, most of any manganese in the cement is precipitated as manganous ammonium phosphate with the magnesium ammonium phosphate. It is understood in this method that manganese so precipitated shall be calculated as magnesium oxide.

Special Solutions Required

12. *(a) Diammonium Phosphate Solution.*—Dissolve 25 g. of $(NH_4)_2HPO_4$ in 100 ml. of water.

(b) Ammonium Nitrate Wash Solution.—Dissolve 100 g. of NH_4NO_3 in 800 ml. of water and add 200 ml. of NH_4OH (sp. gr. 0.90).

Procedure

13. Acidify the filtrates reserved in the determination of calcium oxide (Section 11) with HCl and concentrate to about 150 ml. Add to this solution about 10 ml. of $(NH_4)_2HPO_4$ solution and cool the solution by placing in a beaker of ice water. After cooling, add NH_4OH drop by drop, while stirring constantly, until the crystalline magnesium ammonium phosphate begins to form, and then in moderate excess (5 to 10 percent of the volume of the solution), the stirring being continued for several minutes. Set the solution aside for at least 8 hr. in a cool atmosphere, and then filter. Redissolve the precipitate thus obtained in hot diluted HCl (1:4), dilute the solution to about 100 ml., add 1 ml. of the $(NH_4)_2HPO_4$, and NH_4OH drop by drop, while stirring constantly, until the precipitate is again formed as described and the ammonia is in moderate excess. Then cool, allow to stand for about 2 hr., filter, and wash with two 10-ml. portions of NH_4NO_3 wash solution. Place in a weighed platinum crucible, slowly char the paper, and carefully burn off the resulting carbon. Ignite the precipitate at 1,100 to 1,200 C. to constant weight, taking care to avoid bringing the pyrophosphate to melting. The weight of magnesium pyrophosphate obtained multiplied by 72.4 gives the percentage of MgO.

Alternate Methods

Note.—Either of the methods in Sections 14 to 17 may be used when magnesium oxide alone is to be determined, except that in case of dispute the results obtained according to Section 13 shall govern.

Rapid Determination by Acid–Alkali Method

Special Solutions Required

14. *(a) Trinitrobenzene Indicator.*—Dissolve 1.0 g. of c.p. 1-3-5-trinitrobenzene in 100 ml. of ethanol (95 to 100 percent).

(b) Phenolphthalein Indicator.—Dissolve 0.4 g. of c.p. phenolphthalein in 100 ml. of ethanol (50 percent).

(c) Standard Sodium Hydroxide Solution.—Dissolve 13.0 g. of sodium hydroxide in water, add 10 ml. of a freshly filtered, saturated barium hydroxide solution, and dilute to 1 liter with distilled water which has been recently boiled and cooled. Shake the solution from time to time for several hours, and filter into a tubulature bottle fitted with an automatic burette. Protect the solution from CO_2 in the air, with soda-lime tubes at the top of the bottle and the burette.

The solution as prepared will be approximately ⅓ *N*. Standardize against acid potassium phthalate or benzoic acid acidimetric standards furnished by the National Bureau of Standards (Standard Samples Nos. 84 and 39), using the methods in the certificates accompanying the standard samples. Determine the exact normality of the solution, and calculate its MgO equivalent on the basis that 1 ml. of a normal solution is equivalent to 0.02016 g. of MgO.

(d) Standard Acid Solution.—Dilute 32.0 ml. of HCl (sp. gr. 1.19) or 26.0 ml. of HNO_3 (sp. gr. 1.42) to 1 liter with distilled water. This solution will be slightly in

excess of ⅓ *N*. Standardize against the standard sodium hydroxide solution, using phenolphthalein indicator, and adjust by dilution until the two solutions are of equal strength.

(e) Potassium Iodide–Starch Paper.—Mix equal volumes of a 5 percent potassium iodide solution and a 1 percent soluble starch solution, and dip strips of filter paper into the mixture.

Procedure

15. *(a)* To 5.0 g. of the sample of cement in a 600-ml. beaker, add about 50 ml. of water and 50 ml. of diluted HCl (1:1), and boil until the cement is completely in solution, excepting possibly some SiO_2 which may separate out (Note 1). Then add 5 ml. of saturated bromine water and continue the boiling until the excess bromine is completely expelled, as indicated by the absence of a blue coloration on potassium iodide–starch paper when held in the issuing steam. Then dilute the solution to about 250 ml. with hot water and add NaOH solution (20 percent) to the boiling solution from a pipette until the excess acid is neutralized and a permanent precipitate just forms. Continue the boiling, carefully add diluted HCl (1:1) from a pipette until the precipitate dissolves and the solution assumes a yellow ferric chloride color, avoiding much excess of acid. Wash down the sides of the beaker with hot water and continue the boiling for a minute or two, and then remove the beaker from the burner.

Note 1.—Some samples of cement, particularly those containing considerable iron or manganese, may require longer boiling or the addition of slightly more HCl to effect complete solution.

(b) Cautiously add to the solution 4.0 g. of calcium carbonate (weighed to the nearest 0.1 g.). This amount should be sufficient to completely neutralize the acid, with some excess. Dilute the solution to about 400 ml. with hot water and boil vigorously for about 10 min. Remove the beaker from the burner or hot plate and from a burette carefully add $KMnO_4$ (0.5 percent) to the hot solution, while stirring vigorously, until the supernatant liquid shows a faint pink color after settling a moment. Avoid the use of more $KMnO_4$ than necessary to produce a faint pink color. Continue the boiling for 2 min., add 2.0 ml. of ethanol, and continue the boiling for a few minutes or until the pink color has disappeared (Note 2).

Note 2.—The purpose of the addition of $KMnO_4$ is to remove manganese from the sample, which otherwise would be precipitated and reported as MgO. The $KMnO_4$ in a hot solution oxidizes the manganese to insoluble MnO_2 and is itself reduced to MnO_2. The ethanol precipitates the excess $KMnO_4$. In samples containing little or no manganese, this portion of the procedure may be omitted.

(c) Transfer the contents of the beaker to a 500-ml. volumetric flask, cool to room temperature, dilute to the mark, and mix by shaking. Filter the solution through dry paper and after discarding the first 10 or 20 ml. of filtrate transfer 200 ml. of the filtrate with a pipette to a 500-ml. Erlenmeyer flask. Heat the solution in the flask to boiling and add 3.0 ml. of trinitrobenzene indicator. Then add standard sodium hydroxide solution, 1.0 ml. at a time, with intermittent boiling for a few seconds, until the magnesium is completely precipitated and a definite pink color persists on boiling. Record the total amount of NaOH used (Note 3).

Note 3.—Enough standard alkali should be added to completely precipitate the magnesium, without too large an excess which might cause some precipitation of calcium. A guide to proper procedure is the amount of back titration with acid, which should be held between 1.0 and 2.0 ml. (after being doubled). A little experience with the color change of the trinitrobenzene indicator will enable the operator to hold the back titration between these limits.

(d) Transfer the solution to a 250-ml. volumetric flask, cool to room temperature, dilute to the mark, and mix by shaking. Filter the solution through a dry paper into a graduated cylinder, discarding the first 10 or 20 ml. of filtrate, until 125 ml. of the filtrate are secured. Transfer 125 ml. of the filtrate to a flask, add a few drops of phenolphthalein indicator, and titrate the solution with standard acid solution to the disappearance of the pink color.

(e) Calculation.—If the acid and alkali solutions are of equal strength, the quantity of alkali in milliliters minus twice the quantity of acid in milliliters is equivalent to the MgO in a 2-g. sample:

$$\text{MgO, percent} = \frac{100(A - 2B)}{2} \times C$$

where:

A = milliliters of standard alkali,
B = milliliters of standard acid, and
C = weight of MgO in grams per milliliter of standard alkali.

*Rapid Determination by Titration of Magnesium Oxyquinolate***

Special Solutions Required

16. *(a) 8-Hydroxyquinoline Solution (1.25 percent).*—Dissolve 25 g. of 8-hydroxyquinoline in 60 ml. of glacial acetic acid. When the solution is complete, dilute to 2 liters with cold water. One milliliter of this solution is equivalent to 0.0016 g. of MgO.

(b) Sodium Thiosulfate Solution (0.1 N).—Dissolve 25 g. of $Na_2S_2O_3.5H_2O$ in 200 ml. of water and dilute to 1 liter. Standardize this solution either on sodium oxalate through a permanganate solution, or on arsenious oxide through a solution of resublimed iodine. Standard Samples Nos. 40 and 83 of the National Bureau of Standards are convenient for this purpose. One milliliter of exactly 0.1 *N* sodium thiosulfate solution is equivalent to 0.000504 g. of MgO.

(c) Potassium Bromate–Potassium Bromide Solution (0.2 N).—Dissolve 20 g. of KBr and 5.57 g. of $KBrO_3$ in 200 ml. of water and dilute to 1 liter. Obtain the ratio of this solution to the standard sodium thiosulfate solution as follows: To 200 ml. of water in a 400-ml. beaker add exactly 25 ml. of bromate solution. Add 20 ml. of HCl (sp. gr. 1.19), stir, and add immediately 10 ml. of KI solution. Mix well and titrate at once with the sodium thiosulfate solution until nearly colorless. Add 2 ml. of starch solution, and titrate to the disappearance of the blue color.

(d) Potassium Iodide Solution (25 percent).—Dissolve 25 g. of KI in 100 ml. of water.

(e) Starch Solution.—To 500 ml. of boiling water add a cold suspension of 5 g. of soluble starch in 25 ml. of water, cool, add a cool solution of 5 g. of NaOH in 50 ml. of water, add 15 g. of KI and mix thoroughly.

Procedure

17. *(a)* To 0.5 g. of the sample of cement in a 400-ml. beaker add 10 ml. of water and 10 ml. of HCl (sp. gr. 1.19). Heat gently and grind any coarse particles with the flattened end of a glass rod until decomposition is complete. Add hot water to make a total volume of 100 ml.

(b) Add 3 drops of methyl red indicator (0.2 percent in ethanol) to the solution and then add NH_4OH (sp. gr. 0.90) until the solution is distinctly yellow. Heat this solution to boiling and boil for 1 to 2 min. Remove from the burner or hot plate and allow to stand until the precipitate has settled. Filter the solution without delay and

** See Note preceding Section 14.

wash the precipitate twice with a hot solution of NH_4Cl (2 percent). Then transfer the precipitate with the filter paper to the beaker and dissolve in 10 ml. of diluted HCl (1:1). Dilute to about 100 ml. and heat to boiling. Reprecipitate, filter, and wash the hydroxides as above. Add 1 ml. of NH_4OH (sp. gr. 0.90) to the filtrate. Heat the filtrate to boiling and while boiling add 25 ml. of a hot solution of $(NH_4)_2C_2O_4.H_2O$ (4 percent) and continue the boiling for 2 min. Continue the digestion on the steam bath for 10 to 15 min.

(c) Cool the solution to 70 C. and add 10 to 25 ml. of the 8-hydroxyquinoline reagent (Note 1) and then 4 ml. of NH_4OH (sp. gr. 0.90) per 100 ml. of solution. Stir the solution on a mechanical stirring machine for 15 min. and set aside until the precipitate has settled (Note 2). Then filter the solution and wash the precipitate with hot diluted NH_4OH (1:40). Dissolve the precipitate in 50 to 75 ml. of the hot diluted HCl (1:9), dilute the resulting solution to 200 ml., and then add 15 ml. of HCl (sp. gr. 1.19). Then cool the solution to 25 C. and add 10 to 35 ml. of standard bromate solution (Note 3) from a pipette. Stir the solution and allow to stand for about 30 sec. to insure complete bromination. Then add 10 ml. of the KI solution. Stir the resulting solution well and then titrate with the standard sodium thiosulfate solution until the color of the iodine becomes faintly yellow. At this point add 2 ml. of the starch solution and titrate the solution to the disappearance of the blue color.

Note 1.—An excess of the 8-hydroxyquinoline reagent should be used. If it is small the result of the determination of MgO may be low; on the other hand, if large, the result may be high. The following guide may be used:

Approximate Content of Magnesium Oxide, Percent	*Approximate Amount of Reagent Required, ml.*
0 to 1.5	10
1.5 to 3.0	15
3.0 to 4.5	20
4.5 to 6.0	25

Note 2.—The precipitate should be filtered within an hour. Prolonged standing may cause high result.

Note 3.—The amount of the standard bromate solution used may be as follows:

Approximate Content of Magnesium Oxide, Percent	*Amount of Standard Bromate Solution, ml.*
0 to 1	10
1 to 2	15
2 to 3	20
3 to 4	25
4 to 5	30
5 to 6	35

(d) Calculation.—The percentage of MgO in a 0.5-g. sample may be calculated as follows:

$$\text{MgO, percent} = 200(A - B) \times C$$

where:

A = milliliters of standard sodium thiosulfate solution equivalent to the number of milliliters of standard bromate solution used,

B = milliliters of sodium thiosulfate solution required in the titration, and

C = weight of MgO in grams per milliliter of standard sodium thiosulfate solution.

Sulfur Trioxide

Procedure

18. To 1 g. of the sample add 25 ml. of cold water and 5 ml. of HCl (sp. gr. 1.19). Heat the solution and grind the material with the flattened end of a glass rod until it is evident that decomposition of the cement is complete. Dilute the solution to 50 ml. and digest on a steam bath for 15 min., filter, and wash the residue thoroughly with hot water. Dilute the solution to 250 ml., heat to boiling, add slowly, drop by drop from a pipette, 10 ml. of a hot $BaCl_2$ solution (10 percent), and continue the boiling until the precipitate is well formed. Then digest the solution on the steam bath for at least 3 hr., preferably overnight. Filter the precipitate, wash, place the paper and contents in a weighed platinum crucible, and slowly char and consume the paper without flaming. Then ignite, and weigh the $BaSO_4$. The weight obtained multiplied by 34.3 gives the percentage of SO_3. The acid filtrate obtained in the determination of the insoluble residue may be used for the estimation of SO_3 instead of using a separate sample.

Loss on Ignition

Procedure

19. Heat 1 g. of the sample in a weighed, covered platinum crucible of 20 to 25-ml. capacity, as follows, using either method 1 or 2 as specified.

(a) Method 1.—Place the crucible in a hole in an asbestos board clamped horizontally, so that about three fifths of the crucible projects below the board, and heat at a full red heat (900 to 1,000 C.) for 15 min.; check the loss in weight by a second heating for 5 min. Take care to wipe off particles of asbestos that may adhere to the crucible when withdrawn from the hole in the board. Greater neatness and shortening of the time of heating may be secured by making a hole to fit the crucible in a circular disk of sheet platinum and placing this disk over a somewhat larger hole in an asbestos board.

(b) Method 2.—Place the crucible in a muffle furnace at any temperature between 900 and 1,000 C. for 15 min., and check the loss in weight by a second heating for 5 min.

Sodium Oxide and Potassium Oxide

Special Solutions Required

20. *(a) Chloroplatinic Acid.*—Dissolve 5 g. of $H_2PtCl_6.6H_2O$ in 100 ml. of water.

(b) Gladding Wash.—Dissolve 100 g. of NH_4Cl in 500 ml. of water, add 5 to 10 g. of pulverized pure K_2PtCl_6 to the solution, and shake the mixture frequently for 6 to 8 hr. Allow the mixture to stand at least 12 hr. and filter. The residue may be used for the preparation of a new supply of the wash.

Procedure

21. *(a)* Weigh 5 g. of the sample of finely pulverized cement and mix it with 1 g. of NH_4Cl by grinding the two together in an agate mortar. Add 4 g. of $CaCO_3$ to the mixture and continue the grinding until the ingredients are thoroughly mixed. Place about 0.5 cm. of $CaCO_3$ on the bottom of a 40 to 60 ml. platinum crucible, add the above mixture to the crucible, and cover the mixture with about 0.5 cm. of $CaCO_3$. Mount the crucible through a hole in an asbestos board about 0.3 cm. in thickness, so that the crucible projects about 1 cm. above the board. Cover the crucible with a well-fitting cover and set a platinum crucible containing water on it. The purpose of the second crucible is to prevent the loss of alkali by volatilization and this crucible must be kept

filled with water through the entire period of ignition. Heat the crucible at a very low temperature at first and gradually raise the temperature within 1 hr. to a bright red heat. At no time should the temperature be raised so fast that white NH_4Cl fumes can be seen issuing from the crucible. Finally, ignite the crucible at 900 to 1,000 C. for 1 hr.

(b) With the aid of hot water, remove the sintered material from the crucible and let the sinter digest with about 150 ml. of water in a casserole on a water bath for about 4 hr. If there are still lumps in the casserole, break them up with a pestle or glass rod. Allow the mixture to digest on the water bath 4 hr. more, or longer. Boil the mixture for 1 min., allow the residue to settle, and decant the clear solution through a filter paper into a large beaker. Add 30 ml. of water to the casserole, bring the mixture to a boil, allow the residue to settle, and decant the clear filtrate through the same filter paper (Note). Perform three more times this addition of water and decantation. Finally, wash the residue into the filter paper, rinse the casserole, and wash the residue once with hot water.

NOTE.—If it is desired to speed up the work without allowing the residue to settle so as to give a clear solution to decant easily, filter the solution at once, leaving as much of the residue in the dish as possible, discharge the filtrate held in the stem of the funnel by tapping the funnel or lifting the filter paper a little out of the funnel, and wash the residue on the filter paper back into the dish.

(c) Combine the filtrates and washings and evaporate them to about 50 ml. Add 3 or 4 g. of $(NH_4)_2CO_3$ to the solution, and boil it for 1 min. Filter the solution, and wash the residue six times with a cool solution of $(NH_4)_2CO_3$ (1 percent) which contains a little NH_4OH. Add 10 ml. of a solution of $(NH_4)_2C_2O_4$ (5 percent) and 2 or 3 ml. of NH_4OH (sp. gr. 0.90) to the filtrate. Evaporate the solution to about 20 ml., filter into a dish, and wash the residue with hot water. Add 1 ml. of H_2SO_4 (sp. gr. 1.84) to the filtrate and evaporate it to dryness.

(d) Ignite the residue in the dish carefully until the excess H_2SO_4 is driven off and then raise the temperature to a dull red heat. Cool the dish, dissolve the residue in 50 ml. of water, and add 2 ml. of the $(NH_4)_2C_2O_4$ (5 percent) and 2 or 3 ml. of NH_4OH (sp. gr. 0.90) to the solution. Evaporate the solution to about 10 ml., filter the solution into a platinum dish, and wash the residue with hot water. Add 0.5 ml. of H_2SO_4 (sp. gr. 1.84) to the filtrate and evaporate it to dryness. Ignite the residue, gradually raising the temperature to 600 to 700 C., until all the excess H_2SO_4 and ammonium salts are expelled. Cool the dish, dissolve the residue in a small amount of water, evaporate the solution to dryness, ignite the residue at 600 to 700 C. for 15 min., cool it in a desiccator, and weigh. Dissolve the residue in about 20 ml. of hot water and filter the solution. Wash the filter paper with hot water and put it in the dish. Ignite carefully until the paper is consumed and then continue the ignition at 600 to 700 C. for 10 min. Cool the dish in a desiccator, and weigh. The difference between these two weights represents the weight of the alkali as Na_2SO_4 and K_2SO_4.

(e) Add 1 to 2 ml. of HCl (sp. gr. 1.19) to the filtrate in a vessel made of glass, silica, or porcelain and evaporate it to about 10 ml. To the solution, add 6 ml. of the solution of chloroplatinic acid for each 0.10 g. of the mixed sulfates and add 3 ml. in excess. Evaporate the solution on a water bath to a thick syrup, carrying this evaporation as far as possible without allowing the solution to go to dryness. The syrupy solution should solidify on cooling. Add 100 ml. of ethanol (85 percent) to the solution while stirring thoroughly, and allow the precipitate of potassium chloroplatinate (K_2PtCl_6) to settle for just 3 hr. Filter the clear liquid through a dried and tared Gooch crucible with a mat of asbestos or a fused-in fritted glass disk. Wash the precipitate five times

by decantation with ethanol (85 percent) and then rinse the crucible three times with the ethanol. Wash the precipitate three times by decantation with the Gladding wash, stirring the precipitate thoroughly each time. Transfer the precipitate to the crucible with the Gladding wash, taking care that none remains in the original vessel, and finally wash the crucible and contents six times with ethanol (85 percent). Dry the crucible at 105 to 110 C. for at least 3 hr. Cool, and weigh it. The difference between these two weights represents the weight of K_2O as K_2PtCl_6.

(f) Calculate the percentages of Na_2O and K_2O in the sample as follows:

$$\text{Wt. of } K_2SO_4 = \text{wt. of } K_2PtCl_6 \times 0.3584$$
$$\text{Wt. of } Na_2SO_4 = \text{wt. of } (K_2SO_4 + Na_2SO_4) - \text{wt. of } K_2SO_4$$
$$Na_2O\text{, percent} = \text{wt. of } Na_2SO_4 \times 0.4364 \times 20$$
$$K_2O\text{, percent} = \text{wt. of } K_2PtCl_6 \times 0.1937 \times 20$$

Water-Soluble Alkali

Note.—The determination of water-soluble alkali according to Section 22 should not be considered as a substitute for the determination of total alkali according to Section 21. Moreover, it is not to be assumed that in the procedure of Section 22 all water-soluble alkali is obtained that may be in the cement. A uniform method is essential where there is a specified limit on the content of water-soluble alkali or where several lots of cement are compared on the basis of water-soluble alkali.

Procedure

22. *(a)* Weigh 25 to 150 g. of the sample (Note 1) into a large beaker and add 250 ml. of water to the cement, while stirring thoroughly (Note 2). Let the mixture stand for 30 min. at room temperature, stir it again, and filter it through a Büchner funnel. Return the residue to the original beaker, rinse the funnel with 150 ml. of water into the beaker, stir the mixture thoroughly, and let it stand 30 min. at room temperature. Again stir the solution and filter it through the Büchner funnel. Return the residue to the beaker and rinse the funnel with 100 ml. of water into the beaker. Stir the mixture thoroughly, and let it stand 30 min. at room temperature. Stir it and filter it as before, discard the residue without washing, and follow the procedure described in either Paragraph *(b)* or Paragraph *(c)* (Note 3).

Note 1.—The amount of sample taken for analysis depends on the content of water-soluble alkali, varying from 25 g. for 0.5 percent or more to 150 g. for 0.1 percent or less.

Note 2.—As the amount of water-soluble alkali obtained depends on the manner in which it is leached out of cement, it is important that the procedure be followed closely.

Note 3.—In most cases the procedure described in Paragraph *(b)* is to be preferred because it is simpler and usually gives all the data necessary.

(b) Follow the procedure as described in Section 21 *(c)* and *(d)*. Calculate as Na_2O the percentage of water-soluble alkali in the sample, as follows:

$$Na_2O\text{, percent} = \frac{\text{wt. of sulfates} \times 0.4364}{\text{wt. of sample}} \times 100$$

(c) If it is required that water-soluble alkali be reported as water-soluble Na_2O and water-soluble K_2O, follow the procedure as described in Section 21, starting with Paragraph *(c)* and making the necessary changes in the formulas of Paragraph *(f)* due to the weight of sample taken for analysis. If desired, a measured portion of the combined filtrates may be taken for the steps following the leaching in order to avoid the use of a large amount of chloroplatinic acid.

Phosphorus Pentoxide

Method A

Special Solutions Required

23. *(a) Ammonium Molybdate Solution.*—Dissolve 100 g. of molybdic acid (85 percent MoO_3) in a mixture of 400 ml. of water and 100 ml. of NH_4OH (sp. gr. 0.90) and cool the solution to room temperature. While stirring constantly, pour this solution very slowly into a cooled mixture of 500 ml. of water and 400 ml. of HNO_3 (sp. gr. 1.42). No precipitate should form that does not redissolve upon stirring. Add 1 drop of a solution of $(NH_4)_2HPO_4$ (25 g. of the salt per 100 ml. of water) to the solution, shake it thoroughly, and allow it to stand at least 24 hr. before use. Filter portions of the solution as needed.

(b) Magnesia Mixture.—Dissolve 50 g. of $MgCl_2.6H_2O$ and 100 g. of NH_4Cl in 500 ml. of water. Make the solution slightly alkaline with NH_4OH and allow it to stand at least 12 hr. Filter the solution, acidify it with HCl, and dilute to 1 liter.

Procedure

24. Weigh 1 to 3 g. of the sample (Note 1) and 10 g. of NH_4NO_3 into a 150-ml. beaker. Mix the contents, treat with 10 ml. of HNO_3 (sp. gr. 1.42), and stir quickly, using the flattened end of a glass rod to crush lumps of cement, until the cement is completely decomposed and the thick gel of SiO_2 is broken up. Cover the beaker with a watch glass, place it on a water bath or a hot plate at approximately 100 C. for 15 to 20 min., and stir the contents occasionally during the heating. Add 20 ml. of hot water to the beaker and stir the contents. If the cement contains an appreciable amount of manganese, as shown by the presence of a red or brown residue, add a few milliliters of $NaNO_2$ solution (5 percent) to dissolve this residue. Boil the contents of the beaker until all nitrous fumes are completely expelled. This should not take more than 5 min., and water should be added to replace any lost by evaporation. Filter into a 500-ml. Erlenmeyer flask under suction and with a platinum cone to support the filter paper, and wash the residue of SiO_2 until the volume of filtrate and washings is about 150 ml. Heat the solution to 85 C. and add 50 to 100 ml. of the ammonium molybdate solution. Stopper the flask and shake it vigorously for 5 min., then set it aside for 30 min. Filter the precipitate, rinsing the flask five times and washing the filter paper eight times with a cold solution of KNO_3 (1 percent). Put the original flask under the funnel containing the precipitate. Pour 25 ml. of diluted NH_4OH (1:4) over the precipitate and around the upper edges of the filter paper until the precipitate is entirely dissolved. Wash the paper three times with cold water, twice with diluted HCl (1:1), and finally three times with cold water. Acidify the solution with HCl and add to it 1 ml. of a solution of citric acid (35 g. of the acid per 100 ml. of water) to hold traces of iron, if any, in solution. Cool the solution to room temperature and transfer it to a 400-ml. beaker. The volume should now be about 150 ml. Add 25 ml. of magnesia mixture to the solution, and then, while stirring constantly, add drop by drop 50 ml. of NH_4OH (sp. gr. 0.90) at such a rate that 5 min. are required for the addition. Allow the mixture to stand 4 hr. or longer. Filter the precipitate, and wash it a few times with diluted NH_4OH (1:20). Dissolve the precipitate into the original beaker by pouring 25 ml. of diluted HCl (1:1) on the precipitate. Wash the filter paper thoroughly with diluted HCl (1:20). With the washings and water, dilute the solution to 50 to 100 ml., and add to it 1 to 2 ml. of magnesia mixture. While stirring constantly, add NH_4OH slowly to the solution as before. Allow the mixture to stand 2 hr. or longer. Filter the precipitate, scrub and rinse the beaker, and wash the precipitate ten times with diluted NH_4OH (1:20). Ignite the pre-

cipitate in a weighed crucible at 1,100 to 1,200 C. to constant weight. Multiply the weight of the magnesium pyrophosphate ($Mg_2P_2O_7$) by 0.6379 to get the weight of the phosphorus in the sample as P_2O_5 (Note 2).

NOTE 1.—The amounts of sample and reagents used depend on the content of phosphorus in the cement. The minimum requirements are sufficient if the cement contains 0.5 percent P_2O_5 or more. The maximum amounts are required if the content of P_2O_5 is 0.1 per cent or less.

NOTE 2.—If a determination of phosphorus is required, the weight of the aluminum oxide and ferric oxide ($Al_2O_3 + Fe_2O_3$), as obtained by the method described in Section 7, shall be corrected for the amount of the P_2O_5 found.

Method B, Alternate Procedure

(In case of dispute, Method A should be used)

Reagents

25. *(a) Ammonium Molybdate Solution.*—Prepare the solution in accordance with Section 23 *(a)*.

(b) Standard Sodium Hydroxide (Approximately 0.3 N).—Dissolve 12 g. of NaOH in a liter of water that has been freshly boiled to expel CO_2 and cooled. Add 10 ml. of a freshly filtered, saturated solution of $Ba(OH)_2$. Shake the solution frequently for several hours, and filter it. Protect it from contamination by CO_2 in the air. Standardize the solution against standard acid potassium phthalate (standard sample No. 84) or benzoic acid (standard sample No. 39) furnished by the National Bureau of Standards, according to the directions furnished with the standard. If the solution is exactly 0.3 *N*, it is equivalent to 0.0009261 g. of P_2O_5 per milliliter (Note). The value of the solution in terms of grams of P_2O_5 per milliliter is:

$$A = \frac{N \times 0.0009261}{0.3}$$

where:

A = value of the NaOH solution in grams of P_2O_5 per milliliter, and
N = normality of the solution.

NOTE.—The value of the solution is based on the assumption that the phosphorus in cement is precipitated as $2(NH_4)_3PO_4.12MoO_3$ and that the precipitate reacts with the NaOH solution thus:

$$2(NH_4)_3PO_4.12MoO_3 + 46NaOH =$$
$$2(NH_4)_2HPO_4 + (NH_4)_2MoO_4 + 23Na_2MoO_4 + 22H_2O.$$

As the actual composition of the precipitate is influenced by the conditions under which the precipitation is made, it is essential that all the details of the procedure are followed closely as prescribed.

(c) Standard Sulfuric Acid (Approximately 0.15 N).—Dilute about 4 ml. of H_2SO_4 (sp. gr. 1.84) to 1 liter with water that has been freshly boiled and cooled. Standardize it against the standard NaOH solution.

Procedure

26. *(a)* Weigh 1 to 3 g. of the sample (Note 1) and 10 g. of NH_4NO_3 into a 150-ml. beaker. Mix the contents, treat with 10 ml. of HNO_3 (sp. gr. 1.42), and stir quickly, using the flattened end of a glass rod to crush lumps of cement, until the cement is completely decomposed and the thick gel of SiO_2 is broken up. Cover the beaker with a watch glass, place it on a water bath or a hot plate at approximately 100 C. for 15 to 20 min., and stir the contents occasionally during the heating. Add 20 ml. of hot water to the beaker and stir the contents. If the cement contains an appreciable amount of manganese, as shown by the presence of a red or brown residue, add a few milliliters of

$NaNO_2$ solution (5 percent) to dissolve this residue. Boil the contents of the beaker until all nitrous fumes are completely expelled. This should not take more than 5 min., and water should be added to replace any lost by evaporation. Filter into a 400-ml. beaker under suction and with a platinum cone to support the filter paper, and wash the residue of SiO_2 until the volume of filtrate and washings is about 150 ml. Heat the solution to 69 to 71 C., remove it from the heat source, and immediately treat it with 50 to 100 ml. of the ammonium molybdate solution. Stir the solution vigorously for 5 min., wash down the sides of the beaker with cool KNO_3 solution (1 percent in water freshly boiled to expel CO_2 and cooled), cover the beaker with a watch glass, and allow to stand 2 hr.

NOTE 1.—The amounts of sample and reagents used depend on the content of phosphorus in the cement. The minimum requirements are sufficient if the cement contains 0.5 percent P_2O_5 or more. The maximum amounts are required if the content of P_2O_5 is 0.1 percent or less.

(b) Using suction, filter the precipitate (Note 2) decanting the solution with as little disturbance to the precipitate as possible. Stir the precipitate in the beaker with a stream of the cool KNO_3 solution, decant the liquid, then wash the precipitate onto the filter. Scrub the stirring rod and beaker with a "policeman," and wash the contents onto the filter. Wash the precipitate until it is acid-free (Note 3), allowing each portion of wash solution to be sucked completely through before adding the next. Transfer the filter and precipitate to the beaker in which the precipitation took place, using small damp pieces of paper to wipe out the funnel and to pick up portions of the precipitate that may remain on it. Add 20 ml. of cool CO_2-free water to the beaker, and break up the filter by stirring rapidly with the "policeman" which was used to scrub the beaker. Add an excess of the standard NaOH solution, stir the contents until all trace of yellow has disappeared, wash down the stirring rod and sides of the beaker with 50 ml. of cool, CO_2-free water, and add 2 drops of phenolphthalein indicator (a neutral 1 percent solution in ethanol). Treat the solution with a measured quantity of the standard H_2SO_4 (0.15 *N*), sufficient to completely destroy the pink color. Complete the titration with the NaOH solution until there is a definite faint pink color which lasts at least 5 min.

NOTE 2.—The filter may be a small ordinary filter paper supported by a platinum cone, or a small Hirsch funnel may be used with filter paper cut to fit and a thin mat of paper pulp or acid-washed asbestos pulp. The filtration should be carried out with care to avoid any loss of the precipitate. The filter should fit well, and the suction should be started before the filtration and maintained until the end of the washing.

NOTE 3.—About ten washings are usually required. Test the tenth washing with one drop of the phenolphthalein indicator and half a drop of the NaOH solution. If a definite pink color lasts at least 5 min., the precipitate is considered to be acid-free; otherwise, continue the washing.

(c) Calculation.—Calculate percentage of P_2O_5 in the cement as follows:

$$P_2O_5, \text{ percent} = \frac{A(B - CD)}{W} \times 100$$

where:

A = value of the NaOH solution in grams of P_2O_5 per milliliter,
B = total volume of NaOH solution used in the titration,
C = volume of H_2SO_4 solution used in the titration,
D = ratio of H_2SO_4 solution to NaOH solution as found in the standardization of the H_2SO_4 solution, and
W = weight of sample.

A

Manganic Oxide

Method A

Special Solution Required

27. *Standard Sodium Arsenite Solution.*—Dissolve in 100 ml. of water 3.0 g. of Na_2CO_3 and then 0.9008 g. of As_2O_3, heating the mixture until the solution is as complete as possible. If the solution is not clear or contains a residue, filter the solution. Cool it to room temperature, transfer it to a volumetric flask, and dilute it to 1 liter. Each milliliter of this solution is approximately equivalent to 0.0003 g. of Mn_2O_3.

Dissolve 0.58 g. of $KMnO_4$ in 1 liter of water and standardize it against 0.0300 g. of sodium oxalate oxidimetric standard furnished by the National Bureau of Standards (standard sample No. 40) according to the directions furnished with the sodium oxalate. Put 30.0 ml. of the $KMnO_4$ solution in a 250-ml. Erlenmeyer flask. Add 60 ml. of diluted HNO_3 (1:4) and 10 ml. of $NaNO_2$ (5 percent) to the flask. Boil the solution until the HNO_2 is completely expelled. Cool the solution and add sodium bismuthate ($NaBiO_3$), and finish by titrating with the standard solution of As_2O_3 in the manner described below for the determination of manganese in cement.

The value of the standard solution of As_2O_3 per milliliter in terms of grams of Mn_2O_3 is:

$$\frac{0.03 \times 0.236 \times 30}{A \times B}$$

where:

A = number of milliliters of the solution of $KMnO_4$ required by 0.0300 g. of $Na_2C_2O_4$, and

B = number of milliliters of the standard solution of As_2O_3 required by 30.0 ml. of the solution of $KMnO_4$.

Procedure

28. *(a)* Weigh 1.0 to 3.0 g. of the sample (Note 1) into a 250-ml. beaker and treat it with 5 to 10 ml. of water and then with 60 to 75 ml. of diluted HNO_3 (1:4). Boil the mixture until the solution is as complete as possible. Add 10 ml. of a $NaNO_2$ solution (5 percent) to the solution and boil it until the HNO_2 is completely expelled (Note 2), taking care not to allow the volume of the solution to become so small as to cause the precipitation of gelatinous SiO_2. There may be some separated SiO_2 which may be ignored, but if there is still a red or brown residue, use more of the $NaNO_2$ solution to effect a complete decomposition and then boil again to expel the HNO_2. Filter the solution into a 250-ml. Erlenmeyer flask and wash the filter paper with water.

Note 1.—The amount of cement taken for analysis depends on the content of manganese, varying from 1 g. for about 1 percent of Mn_2O_3 to 3 g. for 0.25 percent or less of Mn_2O_3.

Note 2.—When $NaNO_2$ is added, the expulsion of HNO_2 by boiling must be complete. If any HNO_2 remains in the solution, it will react with the added $NaBiO_3$ and decrease its oxidizing value. If there is any manganese in the cement, the first small quantity of $NaBiO_3$ should bring out a purple color.

(b) The solution should have a volume of 100 to 125 ml. Cool it to room temperature. To the solution add a total of 0.5 g. of $NaBiO_3$ in small quantities, with intermittent shaking. After the addition is completed, shake the solution occasionally for 5 min. and then add to it 50 ml. of cool diluted HNO_3 (1:33) which has been previously boiled to expel nitrous acid. Filter the solution through a pad of ignited asbestos in a Gooch crucible or a carbon or fritted-glass filter with the aid of suction. Wash the residue four times with the cool diluted HNO_3 (1:33). Titrate the filtrate immediately with the standard solution of As_2O_3. The end point is reached when a yellow color is

obtained free of brown or purple tints and it does not change upon further addition of As_2O_3. Calculate the manganese in the cement as Mn_2O_3.

NOTE 3.—If a determination of manganic oxide is required in addition to a determination of magnesium oxide by Sections 12 to 17, manganese shall be eliminated from the combined filtrates obtained in the aluminum oxide and ferric oxide determination before calcium oxide is precipitated (Section 11), in the following manner:

Acidify the combined filtrates with HCl and evaporate them to a volume of about 100 ml. Add 40 ml. of saturated bromine water to the hot solution and immediately add NH_4OH until the solution is distinctly alkaline. Boil the solution for 5 min. or more, making certain that the solution is at all times distinctly alkaline. Allow the precipitate to settle, filter, and wash with hot water. Discard the precipitate. Acidify the filtrate with HCl and boil until all the bromine is expelled. Make the solution alkaline with NH_4OH and proceed in accordance with Section 11.

Method B, Alternate Procedure

(In case of dispute, Method A should be used)

Special Solution Required

29. *Standard Potassium Permanganate Solution.*—Dissolve 5.63 g. of $KMnO_4$ in 1 liter of water and standardize it against 0.7500 g. of sodium oxalate oxidimetric standard furnished by the National Bureau of Standards (standard sample No. 40) according to the directions furnished with the sodium oxalate.

The value of the standard solution of $KMnO_4$ in terms of grams of Mn_2O_3 per milliliter is:

$$\frac{0.75 \times 0.3534}{A}$$

where:

A = number of milliliters of the solution of $KMnO_4$ required by 0.7500 g. of $Na_2C_2O_4$.

NOTE.—An approximately 0.18 N solution of $KMnO_4$, which is equivalent to about 0.005 g. of CaO per milliliter and is generally used in the routine volumetric determination of CaO in cement and raw materials, is convenient to use. Exactly 0.005 g. of CaO is equivalent to 0.004224 g. of Mn_2O_3.

Procedure

30. *(a)* Place 2 g. of the sample in a 250-ml. beaker and add about 50 ml. of water to the cement. Stir the mixture until it is in suspension and then add about 15 ml. of HCl (sp. gr. 1.19). Heat the mixture gently until the solution is as complete as possible. Add 5 ml. of HNO_3 (sp. gr. 1.42) and 50 ml. of water to the solution and boil it until most of the chlorine has been expelled. If necessary, add hot water to maintain the solution at a volume of about 100 ml. Stop the boiling and add ZnO powder to the solution until the acid is neutralized. Add an excess of 3 to 5 g. of ZnO powder to the solution and boil it for a few minutes.

(b) Without filtering, and while keeping the solution hot (90 to 100 C.) by intermittent or continuous heating, titrate the solution with the standard solution of $KMnO_4$ until a drop of it gives a permanent pink color (Note). When the end point is approached, add the standard solution drop by drop. After each drop stir the solution, allow the precipitate to settle a little, and observe the color of the upper stratum of the solution by looking through the side of the beaker. Calculate the percentage of Mn_2O_3 in the cement by multiplying the burette reading by the value of the standard solution and then by multiplying by 50.

NOTE.—In the case of a cement in which the approximate content of Mn_2O_3 is unknown, a preliminary determination may be made with rapid titration, 0.5 to 1 ml. of the standard solution being added at a time, and without an attempt to keep the solution close to the boiling point.

Insoluble Residue

Procedure

31. To 1 g. of the sample add 25 ml. of cold water and 5 ml. of HCl (sp. gr. 1.19). Heat the solution and grind the material with the flattened end of a glass rod until it is evident that the decomposition of the cement is complete. Dilute the solution to 50 ml. and digest on a steam bath for 15 min. Filter the residue, wash six times with hot water, and digest the filter paper and contents in about 30 ml. of a Na_2CO_3 solution (5 percent), the liquid being held at a temperature just short of boiling for 15 min. Filter the remaining residue, wash twice with hot water, then with a few drops of hot diluted HCl (1:9), and finally eight to ten times with hot water. Ignite at a red heat and weigh as the insoluble residue.

Chloroform-Soluble Organic Substances

Procedure

32. *(a)* Place 40 g. of cement in a large beaker and mix it with 520 ml. of water, starting with a small portion of the water and stirring the slurry until it is free of lumps and is of a uniform, thick consistency before adding the balance of the water. While stirring the slurry to a uniform suspension, add rapidly 185 ml. of HCl (sp. gr. 1.19) and continue the stirring. When the cement is completely decomposed, cool the solution rapidly to room temperature by immersion in cold water, while stirring occasionally. Transfer the solution to a 1000-ml. Squibb separatory funnel (Note 1) and rinse the beaker with a little water. Add 75 ml. of chloroform to the solution, rinsing the beaker with the chloroform in three portions as it is added. Stopper the funnel, shake it vigorously for 5 min., and allow the water and chloroform to separate.

Note 1.—The use of grease to lubricate the stopcocks and glass stoppers of the separatory funnels should be avoided. Wetting the stopcocks with water before using will assist in their easy operation.

(b) Draw off the lower chloroform layer into a 125-ml. Squibb separatory funnel, including the scum (Note 2) with a few milliliters of the aqueous solution, making certain that all the scum is transferred. Shake the funnel vigorously to insure the complete extraction of the scum. Allow the chloroform to separate, and draw it into a 250-ml. Squibb separatory funnel which contains 50 ml. of water and a few drops of HCl, making sure to keep the scum behind in the 125-ml. funnel. Shake the 250-ml. funnel, but not so vigorously as to form a slow separating emulsion. Draw the chloroform into another 250-ml. funnel which contains 50 ml. of water and a few drops of HCl. Shake this funnel as in the case of the first 250-ml. funnel. When the chloroform separates, draw it into an Erlenmeyer flask (Note 3), taking care not to allow any water to enter the flask.

Note 2.—There is usually a dark colored scum at the liquid interface. It may contain chloroform-soluble organic substance after shaking in the funnel where the proportion of water to chloroform is great. It may be concentrated and confined to a small volume by gently twirling the funnel after the scum has been drawn into the narrower part of the funnel.

Note 3.—The liquid is later distilled. No cork or rubber stoppers should be used. A 250- or 300-ml. soil analysis flask, fitted with a condenser tube by means of a ground joint, is satisfactory. The tube may be bent near the neck and the remaining part fitted with a water-cooling jacket. Chloroform thus recovered may be re-used.

(c) Rinse the original large beaker with 25 ml. of chloroform, and add the liquid to the 1000-ml. separatory funnel. Carry out the operations as described above, retaining the original wash water in the 250-ml. funnels. Repeat, using another 25-ml. portion of chloroform.

(d) Distill the combined chloroform extracts in the Erlenmeyer flask until their volume is reduced to 10 to 15 ml. Filter the remaining liquid into a weighed 100-ml. glass beaker or platinum dish (Note 4) through a small filter paper that has been washed with chloroform. Rinse the flask and wash the paper with several small portions of chloroform. Evaporate the extract to dryness (Note 5), and weigh the vessel. Heat it in an oven at 60 C. for 3 min., cool, and weigh. If necessary, repeat the heating and weighing until two successive weighings do not differ by more than 0.0010 g. The higher of the last two weights is taken as the true weight, and the weight of the residue (Note 6) multiplied by 2.5 gives the percentage of chloroform-soluble organic substance in the cement. Report the result to two significant figures.

Note 4.—A platinum dish is preferable, as it quickly attains the temperature of the balance. If a glass beaker is used, it should be allowed to stand in the case of the balance for at least 20 min. before the weighing.

Note 5.—Care should be taken in drying the extract, as many of the chloroform-soluble organic substances are somewhat volatile when heated for a long time at even moderate temperatures. With protection from the accumulation of dust, the solution may be evaporated at room temperature overnight. When a quick evaporation is desired, the solution may be evaporated on a hot plate at a low heat until it is about ⅛ in. in depth, and the evaporation may be finished with a rapid stream of dry air through a glass tube (about 1 cm. in inside diameter) placed close to the surface of the liquid. The stream of air should be continued 5 min. after the residue appears dry. After each heating in the oven at 60 C. pass dry air into the vessel, as before, for a few seconds. The air may be dried by passing it through a cheap desiccant, such as calcium chloride or sulphuric acid, followed by a desiccant of high efficiency, such as magnesium perchlorate or soluble anhydrite, with care taken to avoid the carrying of dust from the desiccant by the air. Instead of using compressed air, which is often contaminated with oil, dirt, and moisture, one can place the chloroform solution under a bell glass and induce a stream of air through the desiccants by means of an aspirator or vacuum pump.

Note 6.—If the organic substance in the cement is tallow, the residue is the fatty acids resulting from the hydrolysis of the tallow in the hot acid solution, and its weight should be multiplied by 1.05 to give the weight of the original glycerides in the tallow. If the original substance is calcium stearate, the residue is stearic acid, and its weight multiplied by 1.07 gives the weight of calcium stearate.

Blank Determination

33. Make a blank determination using 40 g. of the cement, which is ignited at 950 to 1,000 C. for 1 hr. (Note) and reground, and using the same amounts of reagents and procedure as prescribed above, and correct accordingly the result previously determined.

Note.—Care should be taken to completely burn off the organic substance. A 100-ml. flat platinum dish, in which the sample is well spread out, and a muffle furnace are advised for this purpose. If such a furnace is not available, a large high-temperature burner of the Meker type may be used. Thorough stirring of the sample should be done frequently, every 5 min. when a burner is used.

Report

Recommended Order for Reporting Analysis

34. *(a)* The following order is recommended for reporting the results of chemical analysis of Portland cement:

Major Components:

SiO_2	Silicon dioxide
Al_2O_3	Aluminum oxide
Fe_2O_3	Ferric oxide
CaO	Calcium oxide
MgO	Magnesium oxide
SO_3	Sulfur trioxide
Loss on ignition	

Minor Components:

Na_2O	Sodium oxide
K_2O	Potassium oxide
P_2O_5	Phosphorus pentoxide
Mn_2O_3	Manganic oxide

Separate Determinations:

Insoluble residue
Chloroform-soluble organic substances
Water-soluble alkali

(b) The percentages of components should be expressed to the nearest 0.1 percent, except that components present in quantities less than 1 percent should be reported to the nearest 0.01 percent.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF PORTLAND CEMENT

1942

The same as ASTM Designation: C 114–40 T

Free Calcium Oxide in Portland Cement and Clinker

Method A

Special Solutions Required

1. *(a) Indicator.*—Dissolve 1 g. of phenolphthalein in 100 ml. of absolute ethanol, and neutralize the solution with NaOH dissolved in absolute ethanol.

(b) Solvent.—Prepare a solution consisting of one part by volume of U.S.P glycerol (Note 1) and 5 parts by volume of absolute ethanol (Note 2). To each liter of this solution add 2 ml. of the indicator. The solvent should be slightly alkaline (Note 3) to the indicator. If the solvent is colorless, add a diluted solution of NaOH in absolute ethanol until a slight pink color appears. If the initial color is pink, remove it with the standard solution of ammonium acetate and add the solution of NaOH until a slight pink color appears. Heat 60 ml. of the solvent to boiling. If the pink color persists add one small drop of the standard solution of ammonium acetate (0.02 ml., equivalent to 0.0001 g. CaO) to the hot solvent. If the pink color does not disappear, the solvent contains too much alkali, which should be reduced. The solvent, if allowed to stand for a considerable length of time, may become slightly acid and should be checked and, if necessary, readjusted from time to time. (Note 4.)

Note 1.—The glycerol should be U.S.P. or better. According to the eleventh edition of the United States Pharmacopoeia (in effect, June 1, 1936), U.S.P., glycerol should not be less than 95 percent $C_3H_5(OH)_3$ and its specific gravity should not be below 1.249 at 25 C. The use of "chemically pure" glycerol is permissible if it does not contain more water than U.S.P. glycerol. Water is not usually included by the manufacturer in the list of impurities on the label but is usually present.

Note 2.—Absolute ethanol may be replaced by anhydrous ethanol denatured according to Formula No. 3a or 2b of the U. S. Bureau of Internal Revenue. The alcohol is 95 percent ethanol and 5 percent methanol according to Formula No. 3a or 99.5 percent ethanol and 0.5 percent benzol according to Formula No. 2b.

Note 3.—While a solvent which is exactly neutral at the boiling point is the ideal, it is difficult to prepare due to the end point not being sharp and the danger of adding too much ammonium acetate. The error due to slight alkalinity is not more than 0.01 percent in a determination of free calcium oxide and may be disregarded. In making up the

solvent, the end point may be better observed if the solvent is put in a tall cylinder placed on white paper. The solvent may be observed from the top and the color matched with that of acidified solvent in a similar cylinder.

NOTE 4.—Glycerol and ethanol are highly hygroscopic. Every effort should be made to avoid exposing them and other materials unnecessarily to water and CO_2 in air. Bottles with outlet near bottom or fitted with siphon are convenient. They can be filled to the top and protected with tubes containing soda lime. Condensers may also be fitted with such tubes at the top.

(c) Standard Solution of Ammonium Acetate.—Prepare a standard solution of ammonium acetate in absolute ethanol (approximately 0.2 *N*) as follows: Dissolve 16 g. of crystalline ammonium acetate (Note 5) in 1 liter of ethanol. Standardize this solution by titrating against pure calcium oxide that is *freshly* prepared by calcining pure calcium carbonate or calcium oxalate in a platinum crucible at 900 to 1,000 C. to constant weight. When the calcined calcium oxide has cooled in a desiccator, perform the following operations in quick succession: grind it in an agate mortar, weigh out 0.05 to 0.06 g. of it into a dry 200 or 250-ml. Erlenmeyer flask, and add 60 ml. of the solvent to the flask (Note 6). Disperse the calcium oxide in the solution by shaking the flask and attach a reflux condenser (Note 7). Boil the mixture. The ebullition should be positive but not so violent as to cause bumping or excessive evaporation. Then remove the condenser and immediately titrate the solution, while near boiling, with the standard solution of ammonium acetate. Replace the condenser and boil the solution again. Repeat the titrations at intervals (Note 8). Shake the flask frequently between titrations to shorten the time required for the boiling. The titration is complete when no further color appears in the solution during continuous boiling for 1 hr. (Note 9). Calculate the value of the solution in terms of calcium oxide equivalent to each milliliter of the solution.

NOTE 5.—Ammonium acetate is generally sold in a damp condition and should be as dry as possible. It may be dried over a drying agent for two weeks or more.

NOTE 6.—Sometimes pure calcium oxide will cake on the bottom of the flask, particularly if the glycerol is anhydrous. This trouble may be avoided by putting a few grams of clean, dry quartz sand in the flask before the introduction of calcium oxide and solvent.

NOTE 7.—If a new stopper is used and has white powder on it, it should be thoroughly washed before using. A glass tube about 6 mm. in diameter and 50 to 100 cm. in length may be used as an air-cooled condenser, but a short condenser is not recommended because a loss of alcohol is liable to occur through evaporation. In such a case it is necessary to add neutralized ethanol from time to time to maintain the same proportion of glycerol to ethanol. If the proportion is greater than one to three, a partial decomposition of cement may take place. Instead of an ordinary flask, plain tubing, and a stopper, a flask with a ground-in glass stopper and condenser tube may be used. preferably one with a standard taper joint. A water-cooled condenser is the most satisfactory and it may be as short as 1 ft. Some loss of alcohol may also occur through dripping from the condenser during the titrations and should be compensated for by the addition of neutralized ethanol. . .

NOTE 8.—In general the intervals may be 20 min. but they will chiefly depend on the rapidity of the dissolution of calcium oxide. They may be 5 to 10 min. in the beginning and then be increased to 30 min. or 1 hr. in the end. If the solution contains a large amount of dissolved calcium oxide and its boiling is continued a long time without titration, crystals (probably calcium glyceride) may form which dissolve slowly and increase the time required for the completion of titration.

NOTE 9.—The end point will not be the same for a hot solution and a cold solution, especially when a large amount of calcium acetate is present. The titration should always be carried out while the solution is boiling hot. If the end point is determined accurately, the solution will turn pink upon cooling, and this can serve as evidence that the end point has not been greatly overstepped.

Procedure

2. Weigh 1 g. of finely ground clinker or cement (Note 1) into a flask, add 60 ml. of the solvent to the flask, and proceed as in the standardization of the solution of ammonium acetate. The end point is considered to be reached when the content of free calcium oxide in the sample does not increase by more than 0.05 percent during the last 2 hr. of boiling (Note 2). Multiply the burette reading by the value of the standard solution and by 100 to obtain the percentage of free calcium oxide in the sample.

NOTE 1.—The method is designed especially for fresh clinker. As the method does not differentiate between free calcium oxide and free calcium hydroxide, any free calcium hydroxide that may be present will be included in the determination and calculated as free calcium oxide. The method may be applied to cement or aged clinker, if desired, but the possibility of the presence of free calcium hydroxide should be kept in mind.

The sample should be fine enough to pass completely through a standard No. 200 (74-micron) sieve. If it is not, take about 1.2 g. of the sample and sieve it with a small clean No. 200 (74-micron) sieve. Grind the residue in an agate mortar until it is fine enough to pass through the sieve. Mix all the screenings and ground residue thoroughly, grind slightly over 1 g. rapidly in the agate mortar for 2 or 3 min., and take 1 g. for the determination of free calcium oxide. Avoid unnecessary exposure of the sample to the atmosphere. If the sample is fine enough to pass completely through the sieve, grind slightly over 1 g. as above before weighing 1 g. for the determination.

NOTE 2.—No excess of ammonium acetate should be added at any time because an excess of it may react with calcium aluminate and silicates. To avoid such excess, use a small burette or measuring pipette fitted with a glass stopcock or a rubber pinchcock and small tip which delivers about 50 drops per milliliter. If the titrations are far apart and the reagent evaporates in the tip, a few drops may be discarded before each titration and the drops used in titration may be counted and converted in terms of milliliters. It is a good precaution to allow a slight pink color to remain in the solution after each of the early titrations.

Vigorous boiling is more essential with cement than with pure calcium oxide and, if possible, should be so conducted that it is not necessary to shake the flask vigorously at intervals. The flask should not be shaken vigorously while it is disconnected from the condenser because the solvent, if superheated, may boil, expel alcohol vapor, and then draw in air carrying water and carbon dioxide. A good procedure is to bring the solution and sample to boiling rapidly over a bunsen flame in the beginning before placing the flask on a hot plate and connecting it with the condenser. If there is a tendency to bump, it may be reduced by adding glass beads or pure quartz sand to the flask or putting a thin mat of asbestos between the flask and the hot plate.

If in the final titrations there is doubt as to the exact end point, add a drop of the indicator to the quiescent liquid in the flask and carefully observe the point where the indicator strikes the liquid. If no color appears, the end point has been reached. If the sample settles during boiling and leaves a partially clear layer of solution, another way to overcome difficulty in discerning a change in the color of the solution is to swirl the flask after the addition of the solution of ammonium acetate so as to avoid the dispersion of the sample. A strong daylight lamp with a reflector may be used as an aid in the discernment of the end point. The contents of the flask may be matched with similar contents in another flask which contains an excess of ammonium acetate.

If it is necessary to leave the determination uncompleted, remove the flask, add just enough ammonium acetate to discharge the pink color, and stopper the flask tightly. When renewing the determination, boil the mixture before repeating the titrations.

Method B, Alternate Procedure

(In case of dispute, Method A should be used.)

Special Solutions Required

3. *(a) Indicator.*—Prepare the indicator as described in Section 1 *(a)*.

(b) Solvent.—Prepare the solvent as described in Section 1 *(b)*. Either anhydrous $BaCl_2$ or NaCl is used to accelerate the solution of free calcium oxide. If anhydrous $BaCl_2$ is used, dissolve it in the solvent on the basis of 1 g. per 60 ml. of solvent before

the solvent is neutralized (Note). If NaCl is used, add 0.5 g. of it to the flask that contains solvent and freshly prepared calcium oxide or sample at the beginning of the standardization or determination as the case may be.

NOTE.—A convenient way to prepare a large amount of solvent is to heat $BaCl_2.2H_2O$ at 120 to 130 C. for several hours, dissolve it in hot glycerol (100 to 125 C.) without grinding, and mix the solution with ethanol. If the salt is dehydrated at a much higher temperature, it may be slow to dissolve in hot glycerol or solvent even when ground.

(c) Standard Solution of Ammonium Acetate.—Prepare and standardize a solution of ammonium acetate as described in Section 1 *(c)*, using an accelerator as specified in Paragraph *(b)*.

Procedure

4. Determine free calcium oxide in clinker or cement as directed in Section 2, with the following exceptions:

(a) Use anhydrous $BaCl_2$ or NaCl as directed in Section 3 *(b)*.

(b) The end point is considered to be reached when the content of free calcium oxide does not increase by more than 0.05 percent during the last hour of boiling (Note).

NOTE.—If the boiling is prolonged too long, the sample may be partially decomposed and the end point may be obscured by colored decomposition products. Method B has a tendency to give higher results than Method A. Results by Method B should be occasionally checked with Method A.

SILICON DIOXIDE

Rapid Method, Alternate Procedure[1]

Procedure

5. *(a)* Mix thoroughly 0.5 g. of the sample and about 0.5 g. of NH_4Cl in a 50-ml. beaker, cover the beaker with a watch glass, and add cautiously 5 ml. of HCl (sp. gr. 1.19), allowing the acid to run down the lip of the covered beaker. After the chemical action has subsided, lift the cover, add one or two drops of HNO_3 (sp. gr. 1.42), stir the mixture with a glass rod, replace the cover, and set the beaker on a water bath for 30 min. (Note 1). During this time of digestion, stir the contents occasionally and break up any remaining lumps to facilitate the complete decomposition of the cement. Fit a filter paper of medium fineness to a funnel, transfer the precipitate to the filter as completely as possible without dilution, and allow the solution to drain through. Scrub the beaker with a rubber policeman and rinse the beaker and policeman. Wash the filter two or three times with hot diluted HCl (1:99) and then with ten or twelve small portions of hot water, allowing each portion to drain through completely. Reserve the filtrate and washings for the determination of $Al_2O_3 + Fe_2O_3$ (Note 2).

NOTE 1.—A hot plate may be used instead of a water bath if the heat is so regulated as to approximate that of a water bath.

NOTE 2.—Determine $Al_2O_3 + Fe_2O_3$ by the procedure described in Section 7 of the Standard Methods of Chemical Analysis of Portland Cement (ASTM Designation: C 114–40) of the ASTM. Reserve the combined filtrates for the determination of calcium oxide.

(b) Transfer the filter paper and residue to a weighed platinum crucible, dry, and ignite, at first slowly until the carbon of the paper is completely consumed without inflaming, and finally at 1,050 to 1,100 C. for 1 hr. Weigh the residue as $S.O_2$.

[1] In case of dispute the results obtained according to Sections 6, 11, and 13 of the Standard Methods of Chemical Analysis of Portland Cement (ASTM Designation: C 114–40) of the ASTM shall govern.

Calcium Oxide

Rapid Method, Alternate Procedure

Special Solution Required

6. *Standard Potassium Permanganate (approximately 0.18 N).*—Prepare a solution of $KMnO_4$ on the basis of 5.636 g. per liter. The solution should not be filtered through any filter containing organic matter. It is most convenient to siphon off clear solution without disturbing the sediment on the bottom of the bottle. Standardize the solution against 0.7500 g. of sodium oxalate oxidimetric standard furnished by the National Bureau of Standards (standard sample No. 40) according to the directions furnished with the sodium oxalate. If the burette reading is 62.77 ml., the solution contains 0.005636 g. of $KMnO_4$ per milliliter, which is equivalent to exactly 0.005 g. of CaO. Because of impurities and deterioration, the reading in the standardization is usually not 62.77 ml. Calculate the value of the solution in terms of weight of CaO per milliliter as follows:

$$E = \frac{62.77 \times 0.005 \text{ g. per ml.}}{A}$$

where:

E = CaO equivalent of the $KMnO_4$ solution in grams per milliliter, and
A = milliliters of $KMnO_4$ solution required for standardization.

Procedure

7. Add a few drops of NH_4OH to the combined filtrates obtained in the determination of aluminum and ferric oxides, (Note 2, Section 5), and bring the solution to boiling. Add to the boiling solution 25 ml. of boiling ammonium oxalate (5 percent), and continue the boiling for 5 to 10 min.; then allow the solution to stand for 15 to 20 min. Filter, and wash the precipitate eight to ten times with hot water, the total amount of water used in rinsing the beaker and washing not to exceed 75 ml. Wash the precipitate back into the original beaker, and add 200 ml. of water and 10 ml. of diluted H_2SO_4 (1:1). Heat the solution just short of boiling, and titrate it with the standard $KMnO_4$ solution to a permanent pink color. Add the filter paper and macerate it. Continue the titration slowly until the pink color is permanent for 10 sec. Calculate the percentage of CaO in the cement as follows:

$$\text{CaO, percent} = B \times E \times 200$$

where:

B = milliliters of $KMnO_4$ solution required for titration, and
E = CaO equivalent of the $KMnO_4$ solution in grams per milliliter.

Magnesium Oxide

Rapid Method, Alternate Procedure[1]

Procedure

8. Acidify the filtrate from the determination of CaO with HCl and evaporate by boiling to about 250 ml. Cool the solution to room temperature, and treat it with 10 ml. of a solution of $(NH_4)_2HPO_4$ (10 percent) and 30 ml. of NH_4OH (sp. gr. 0.90). Stir the solution vigorously during the addition of NH_4OH and then for 10 to 15 min. longer. Let the solution stand for at least 8 hr. in a cool atmosphere, then filter. Wash the residue five or six times with diluted NH_4OH (1:20) and ignite in a tared crucible, at first slowly until the filter paper is charred and then burned off, and finally at 1,050 to 1,100 C. for 30 to 45 min. Weigh the residue as $Mg_2P_2O_7$ and calculate the percentage of MgO as follows:

$$\text{MgO, percent} = W \times 72.4$$

where W = weight of $Mg_2P_2O_7$.

Blank Determinations

Procedure

9. Make a blank determination for silicon dioxide, aluminum oxide and ferric oxide, calcium oxide (Note), and magnesium oxide, using the same procedures as prescribed in Sections 5 to 8 and using approximately the same amounts of reagents. Correct accordingly the results previously determined.

Note.—When the amount of calcium oxalate is very small, its oxidation by $KMnO_4$ is slow to start. Before the titration, add a little $MnSo_4$ to the solution to catalyze the reaction.

STANDARD METHODS OF SAMPLING AND PHYSICAL TESTING OF PORTLAND CEMENT

1942

The same as ASTM Designation: C 77–40

Scope

1. These methods describe procedures for the sampling and physical testing of Portland cement.

SAMPLING

Size and Number of Samples; By Whom Taken

2. *(a)* Samples for purpose of tests shall weigh at least 4 lb. each when they are to be composited; individual test samples, on which all specified tests are to be made, shall weigh at least 8 lb.

(b) Test samples shall be either individual or composite samples, as may be specified, and one test sample shall represent not more than 400 bbl., unless otherwise specified by the purchaser.

(c) The sampling shall be done by or under the direction of a responsible representative of the purchaser.

Methods of Sampling

3. *(a) From Cars, Trucks, Etc.*—When cement is sampled in cars, trucks, boats, warehouses, etc., one sample shall be taken from one sack in each 40 sacks (one sample per 10 bbl.), and combined to form one test sample. In the case of samples from trucks where the cement is being trucked from one mill, it is permissible to combine the samples from several trucks to form a test sample representing not more than 400 bbl. When bulk shipments are sampled, representative samples shall be taken from well distributed points.

(b) From Bulk Storage.—The cement may be sampled at bulk storage points by any of the following methods:

From the Conveyor Delivering to Storage.—One sample of 4 lb. or more shall be taken from at least each 400 bbl. passing over the conveyor. This may be secured by taking the entire test sample at a single operation, known as the "grab method," or by combining several portions taken at regular intervals, known as the "composite method." When obtaining a composite sample, this shall be secured by combining approximately equal weights of the cement taken at regular intervals, each portion representing approximately 10 bbl. Automatic samplers may be used in obtaining samples.

From Storage at Points of Discharge.—Sufficient cement shall be drawn from the discharge openings to obtain samples representative of the cement, as determined by the appearance at the discharge openings of indicators placed on the surface of the cement directly above these openings before the drawing of the cement is started. One 4-lb. sample shall be taken for at least each lot of 400 bbl.

From Storage by Means of Proper Sampling Tubes.—Tubes inserted vertically may be used for sampling cement to a maximum depth of 10 ft. This method may be used only when the other methods cannot be applied, and great care must be exercised in order to obtain samples that completely represent the contents of the bin. Samples shall be taken at points well distributed over the storage.

Preparation of Sample

4. *(a)* Samples shall be shipped and stored in moistureproof, airtight containers. Before testing, samples shall be thoroughly mixed and then passed through a No. 20 (840-micron) sieve in order to break up lumps and remove foreign materials.

(b) Composite samples for the tests as required in Section 5 shall be prepared by arranging all test samples in groups, each group representing the number of barrels required by the test or tests for which the composite is intended. From each of the test samples in a group, equal portions shall be taken, sufficient in amount to form a composite large enough to permit the making of the required physical or chemical determinations. The composite sample thus prepared shall be thoroughly mixed before using.

Number of Tests

5. *(a)* All required physical tests shall be made on each test sample taken from cars and trucks (Section 3), no test sample to represent more than one car.

(b) Physical tests on samples taken from bins, boats, warehouses, etc. (Section 3) shall be required as follows:

Time of Setting, each test sample representing each 400 bbl.
Fineness, composite sample representing each 800 bbl.
Strength, composite sample representing each 800 bbl.
Autoclave expansion, composite sample representing each 2,000 bbl.

(c) Chemical determinations shall be required as follows:

SO_3, composite sample representing each 800 bbl.
All specified chemical determinations (except SO_3), composite sample representing each 4,000 bbl.

(d) When the total number of barrels sampled is less than that specified for any one of the above test or composite samples, all of the respective physical and chemical tests shall be made on the quantity sampled.

PHYSICAL TESTS

Fineness

Apparatus

6. *(a) Sieves.*—Wire cloth for standard sieves for cement shall be woven (not twilled) from brass, bronze, or other suitable wire, and mounted without distortion on a frame, about 2 in. (5 cm.) below the top of the frame. The joint between the cloth and frame shall be smoothly filled with solder to prevent lodging of the cement. The sieve frame shall be circular, 8 in. (20.32 cm.) in diameter, and shall be provided with a pan

and cover. A standard No. 200 sieve is one having nominally a 0.0029-in. (74-micron) opening, certified by the National Bureau of Standards, and conforming to the requirements for this sieve in the Standard Specifications for Sieves for Testing Purposes (ASTM Designation: E 11) of the ASTM. The correction to the sieving value of the sieve shall be determined by sieving tests made in conformity with the standard specifications for these tests, using a cement standardized for fineness.

(b) Balances.—The balance used in making the fineness test shall conform to the following requirements: The balance shall be enclosed in a glass case. On balances in use the permissible variation at a load of 50 g. shall be plus or minus 0.05 g., and at loads less than 0.1 g. the permissible variation shall be plus or minus 0.01 g. The permissible variations on new balances shall be one-half of these values.

The maximum sensibility reciprocal* permitted at each of the loads specified above shall be twice the value of the permissible variation specified for the load in question.

(c) Weights.—The permissible variations on the weights in use in the fineness test shall be as follows:

Weight, g.	*Permissible Variations, g.*
50	±0.04
20	±0.02
10	±0.014
5	±0.010
2	±0.006
1	±0.004
0.500	±0.003
0.200	±0.002
0.100	±0.001
0.050	±0.001
0.020	±0.001
0.010	±0.001

The permissible variations on new weights shall be one-half of these values.

Procedure

7. *(a)* A 50-g. sample of the cement shall be placed on the No. 200 sieve which shall be thoroughly clean and dry. Washers, shot, and slugs shall not be used on the sieve. The sieve, with pan and cover attached, shall be held in one hand in a slightly inclined position so that the sample will be well distributed over the sieve, at the same time gently striking the side about 150 times per minute against the palm of the other hand on the up stroke. After every 25 strokes, the sieve shall be turned about one-sixth of a revolution in the same direction. The operation shall be continued until not more than 0.05 g. passes through in 1 min. of continuous sieving. The fineness shall be calculated from the weight of the residue on the sieve expressed as a percentage of the weight of the original sample, applying the sieve connection.

(b) Mechanical Sieving.—Mechanical sieving devices may be used, but the cement shall not be rejected if it meets the fineness requirement when tested by the hand method described in Paragraph *(a)*.

* The sensibility reciprocal is a measure of the sensitiveness of a balance, and is the weight required to move the position of equilibrium of the indicating device a definite amount. For a complete definition of sensibility reciprocal, see National Bureau of Standards *Handbook H–22*, pp. 68 and 69.

Mixing Cement Pastes and Mortars

Apparatus

8. *(a) Scales.*—The scales used in weighing materials for neat cement and mortar mixes shall conform to the following requirements: On scales in use the permissible variation at a load of 1,000 g. shall be plus or minus 1.0 g. The permissible variation on new scales shall be one-half of this value. The sensibility reciprocal* shall not be greater than twice the permissible variation.

(b) Weights.—The permissible variations on the weights in use in weighing materials for neat cement and mortar mixes shall be as follows:

Weight, g.	*Permissible Variations, g.*
1000	±0.5
900	±0.45
750	±0.4
500	±0.35
300	±0.3
250	±0.25
200	±0.20
100	±0.15
50	±0.10
20	±0.05
10	±0.04
5	±0.03
2	±0.02
1	±0.01

The permissible variations on new weights shall be one-half of these values.

(c) Glass Graduates.—Glass graduates of 100-ml. to 200-ml. capacities used for measuring the mixing water shall be made to deliver the indicated volume at 20 C. The permissible variation on these graduates shall be plus or minus 1.0 ml.

Temperature and Humidity

9. The temperature of the room and dry materials shall be maintained at not less than 20 C. and not more than 27.5 C. The temperature of the mixing water, moist closet or moist room, and water in the briquet storage tank shall not vary from 21 C. by more than plus or minus 1.7 C. The relative humidity of the moist closet or moist room shall be not less than 90 percent.

Procedure

10. The quantities of dry materials to be mixed at one time shall be 500 g. for neat cement mixtures, and not less than 1,000 nor more than 1,200 g. for briquet mortar mixtures. The proportions of cement or cement and sand shall be stated by weight in grams of the dry materials; the quantity of water shall be expressed in milliliters. The dry materials shall be weighed, placed upon a smooth nonabsorbent surface, thoroughly mixed dry if sand is used, and a crater formed in the center, into which the proper percentage of clean water shall be poured; the material on the outer edge shall be turned into the crater within 30 sec. by the aid of a trowel. After an additional interval of 30 sec. for the absorption of the water, the operation shall be completed by continuous, vigorous mixing, squeezing, and kneading with the hands for 1½ min. During the operation of mixing, the hands shall be protected by rubber gloves.

* Ibid.

Normal Consistency

Apparatus

11. *(a) Vicat Apparatus.*—The Vicat apparatus shall consist of a frame *A* (Fig. 1) bearing a movable rod *B*, weighing 300 g., one end *C*, the plunger end, being 1 cm. in diameter for a distance of at least 5 cm., the other end having a removable needle *D*, 1 mm. in diameter and 5 cm. in length. The rod *B* is reversible, and can be held in any desired position by a screw *E*, and has an adjustable indicator *F* which moves over a scale (graduated in millimeters) attached to the frame *A*. The paste is held in a rigid conical ring *G*, resting on a glass plate *H* about 10 cm. square. The ring shall be made of a noncorroding, nonabsorbent material, and shall have an inside diameter of 7 cm. at the base, 6 cm. at the top, and a height of 4 cm.

(b) In addition to the above, the Vicat apparatus shall conform to the following requirements:

Weight of plunger	300 ± 0.5 g. (0.661 lb. ± 8 grains)
Diameter of larger end of plunger	1 ± 0.005 cm. (0.394 ± 0.002 in.)
Diameter of needle	1 ± 0.05 mm. (0.039 ± 0.002 in.)
Inside diameter of ring at bottom	7 ± 0.3 cm. (2.75 ± 0.12 in.)
Inside diameter of ring at top	6 ± 0.3 cm. (2.36 ± 0.12 in.)
Height of ring	4 ± 0.1 cm. (1.57 ± 0.04 in.)
Graduated scale	The graduated scale, when compared with a standard scale accurate to within 0.1 mm. at all points, shall not show a deviation at any point greater than 0.25 mm.

Normal Consistency, Neat Cement

12. *(a)* A 500-g. sample of the cement, with a measured quantity of water, shall

Table 1.—Percentage of Water for Standard Mortars

Percentage of Water for Neat Cement Paste of Normal Consistency	*Percentage of Water for Mortar of One Cement to Three Standard Sand*[a]
15	9.0
16	9.2
17	9.3
18	9.5
19	9.7
20	9.8
21	10.0
22	10.2
23	10.3
24	10.5
25	10.7
26	10.8
27	11.0
28	11.2
29	11.3
30	11.5

[a] When the proportions of cement to sand are other than one to three by weight, the amount of mixing water shall be calculated from the following formula, upon which Table I is based:

$$y = \frac{2}{3}\frac{P}{n+1} + K$$

where:

y = percentage of water required for the sand mortar,
P = percentage of water required for neat cement paste normal consistency,
n = number of parts of sand to one of cement by weight, and
K = a constant which for the standard sand has the value 6.5.

be kneaded into a paste, as described in Section 10, and quickly formed into a ball with the gloved hands, completing the operation by tossing it six times from one hand to the other, maintained about 6 in. apart. The ball resting in the palm of one hand shall be pressed into the larger end of the conical ring *G*, Fig. 801, held in the other hand, completely filling the ring with paste. The excess at the larger end shall then be removed by a single movement of the palm of the hand. The ring shall then be placed on its

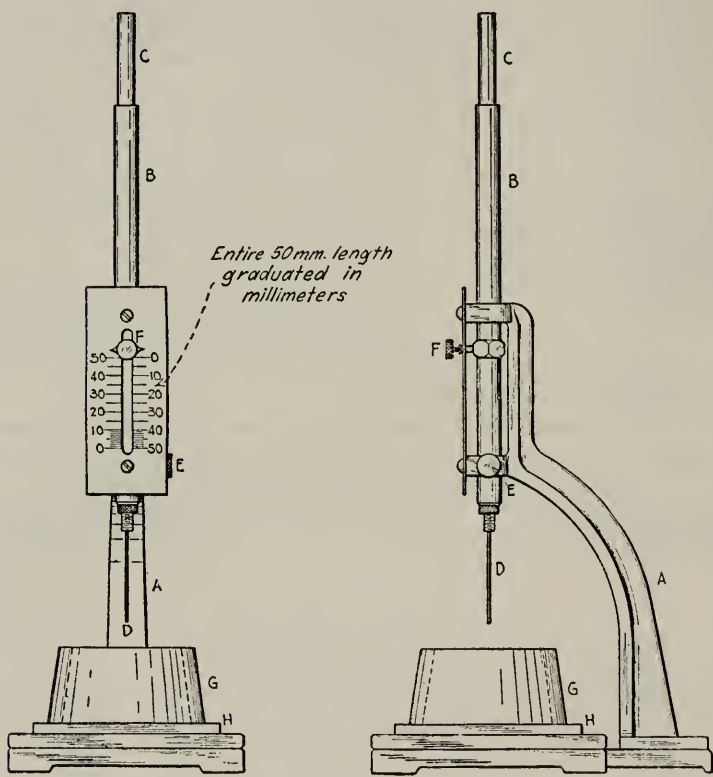


Fig. 801.—Vicat Apparatus.

larger end on a glass plate *H*, and the excess paste at the smaller end sliced off at the top of the ring by a single oblique stroke of a sharp-edged trowel held at a slight angle with the top of the ring, and the top smoothed, if necessary, with a few light touches of the pointed end of the trowel. During these operations care shall be taken not to compress the paste. The paste confined in the ring, resting on the plate, shall be centered under the rod *B*, Fig. 801, the plunger end *C* of which shall be brought in contact with the surface of the paste, and the set-screw *E* tightened. Then the movable indicator *F* shall be set to the upper zero mark of the scale, or an initial reading taken, and the rod released 30 sec. after completion of mixing. The apparatus shall be free from all vibrations during the test.

(b) The paste shall be of normal consistency when the rod settles to a point 10 mm. below the original surface in 30 sec. after being released. Trial pastes shall be made with varying percentages of water until the normal consistency is obtained. Each trial shall be made with fresh cement. The amount of water required shall be expressed in percentage by weight of the dry cement.

Normal Consistency, Standard Mortar

13. The consistency of standard mortar shall depend on the amount of water required to produce a paste of normal consistency from the same sample of cement. Having determined the normal consistency (Section 12) of the cement sample, the consistency of standard mortar made from the same sample shall be as indicated in Table I, the values being in percentage of the combined dry weights of the cement and standard sand.

Soundness

Apparatus

14. A steam apparatus that can be maintained at a temperature between 98 and 100 C., or one similar to that shown in Fig. 802, is recommended. The capacity of this apparatus may be increased by using a rack for holding the pats in a vertical or inclined position.

Test Specimen

15. A pat from cement paste of normal consistency (Section 12), about 3 in. in diameter, ½ in. in thickness at the center, and tapering to a thin edge, shall be made

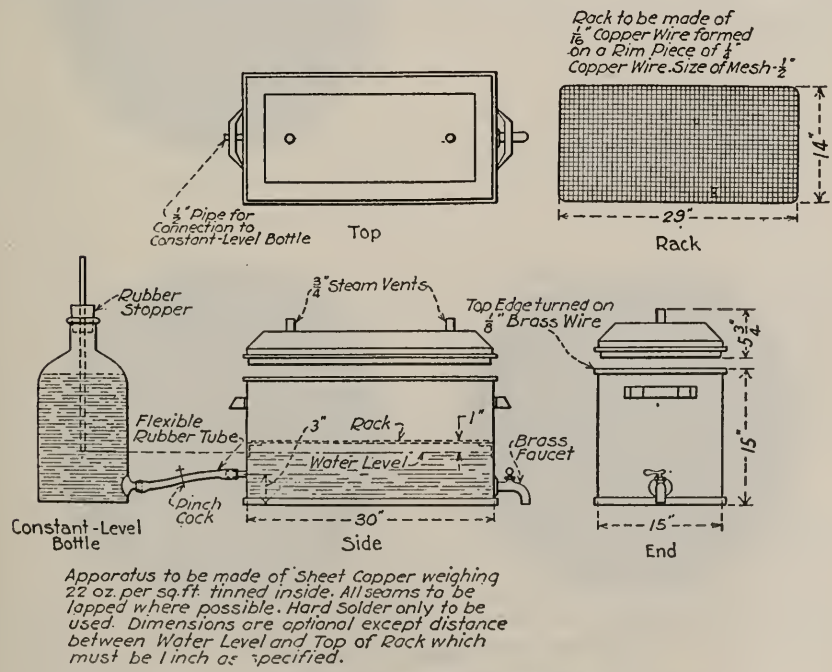
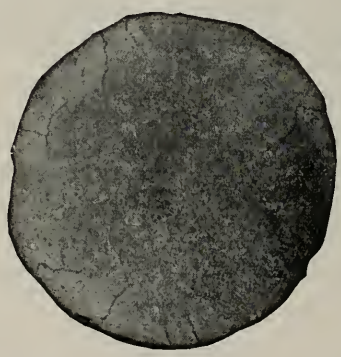


Fig. 802.—Apparatus for Making Soundness Test of Cement.

(a) Shrinkage Cracks Due to Exposure of Pats to Dry Air During Setting.

Distortion



Checking

Cracking

Disintegration

(b) Typical Failures in Soundness Test.

Fig. 803.—Soundness Test Pats.

on a flat, clean glass plate about 4 in. square. In molding the pat, the cement paste shall first be flattened on the glass and the pat then formed by drawing the trowel from the outer edge toward the center to give a rounded surface. The pats used for the time of setting tests by the Gillmore method (Section 21) may be used for soundness tests.

Procedure

16. *(a)* After making, pats shall be stored in the moist closet for 24 hr. The pat on the glass plate shall then be placed in an atmosphere of steam at a temperature between 98 and 100 C., upon a suitable support 1 in. above boiling water for 5 hr.

(b) The pat shall be examined for unsoundness within 1 hr. after removal from the steam apparatus. Unsoundness is usually manifested by change in volume which causes distortion, cracking, checking, or disintegration, as illustrated in Fig. 803 *(b)*.

(c) Should the pat leave the plate, distortion may be detected best with a straightedge applied to the surface which was in contact with the plate.

Time of Setting

Note.—The Vicat Method and the Gillmore Method are alternate procedures, either of which may be used as specified.

Vicat Method

Apparatus

17. The time of setting shall be determined with the Vicat apparatus described in Section 11. (See Fig. 801.)

Test Specimen

18. A cement paste of normal consistency shall be molded in the ring *G*, Fig. 801, as described in Section 12.

Procedure

19. *(a)* The test specimen shall be placed on the glass plate *H*, the needle *D* of the rod *B*, Fig. 801, shall then be lowered until it rests on top of a portion of the glass plate which projects beyond the ring *G*, and the adjustable indicator *F* set to the lower zero mark of the scale or an initial reading taken. The rod *B* shall then be raised, the needle *D* carefully brought in contact with the surface of the paste, and the rod quickly released. The initial set shall be said to have occurred when the needle ceases to pass a point 5 mm. above the glass plate in 30 sec. after being released; and the final set, when the needle does not sink visibly into the paste.

(b) Precautions.—The test specimens shall be kept in a moist closet or moist room during the test. Care shall be taken to keep the needle clean, as the collection of cement on the sides of the needle retards the penetration, while cement on the point may increase the penetration. The time of setting is affected not only by the percentage and temperature of the water used and the amount of kneading the paste received, but also by the temperature and humidity of the air, and its determination is therefore only approximate.

Gillmore Method

Apparatus

20. *(a)* The Gillmore needles shall conform to the following requirements:

Initial Needle:	
Weight	¼ lb. ± 8 grains (113.4 ± 0.5 g.)
Diameter	$\frac{1}{12}$ ± 0.002 in. (2.12 ± 0.05 mm.)
Final Needle:	
Weight	1 lb. ± 8 grains (453.6 ± 0.5 g.)
Diameter	$\frac{1}{24}$ ± 0.002 in. (1.06 ± 0.05 mm.)

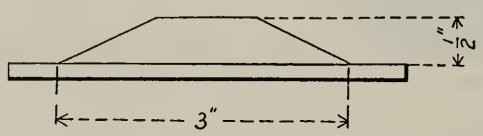
(b) The needle tips shall be cylindrical for a distance of about $\frac{3}{16}$ in. The needle ends shall be plane and at right angles to the axis of the rod and shall be maintained in a clean condition. The Gillmore needles should preferably be mounted as shown in Fig. 804 *(b)*.

Test Specimen

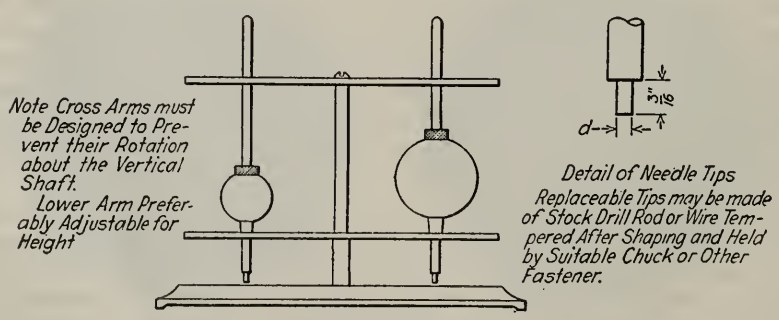
21. A pat from cement paste of normal consistency about 3 in. in diameter, ½ in. in thickness at the center with a flat top and tapering to a thin edge, Fig. 804 *(a)*, shall be made on a flat, clean glass plate about 4 in. square. In molding the pat the cement paste shall first be flattened on the glass and the pat then formed by drawing the trowel from the outer edge toward the center, then flattening the top.

Procedure

22. *(a)* After making, the pats shall be kept in a moist closet or moist room at a temperature of 21 ± 1.7 C. and at a relative humidity of at least 90 percent. In determining the time of setting, the needles shall be held in a vertical position and applied lightly to the surface of the pat.



(*a*) Pat with Top Surface Flattened for Determining Time of Setting by Gillmore Method.



(*b*) Gillmore Needles.

FIG. 804.—Apparatus for Time of Setting Test.

(b) Initial Set.—The cement shall be considered to have acquired its initial set when the pat will bear, without appreciable indentation, the Gillmore needle $\frac{1}{12}$ in. in diameter, loaded to weigh ¼ lb.

(c) Final Set.—The cement shall be considered to have acquired its final set when the pat will bear, without appreciable indentation, the Gillmore needle $\frac{1}{24}$ in. in diameter, loaded to weigh 1 lb.

Tensile Strength

Apparatus

23. *(a) Briquet Molds.*—The molds for making test specimens shall be made of noncorroding metal and shall have sufficient material in the sides to prevent spreading during molding. Gang molds, when used, shall be of the type shown in Fig. 805. The dimensions of the briquet molds shall conform to the following requirements: width of mold, between inside faces, at waist line of briquet, 1 in. with permissible variations of plus or minus 0.01 in. for old molds and plus or minus 0.005 in. for new molds; thickness of new molds measured at point of greatest thickness on either side of mold at waist line, 1 in. with permissible variations of plus 0.004 in. and minus 0.002 in.

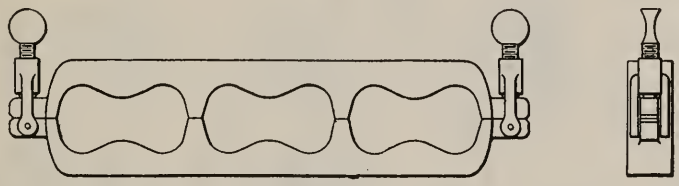


Fig. 805.—Briquet Gang Mold.

(b) Sieves.—The sieves shall conform to the Standard Specifications for Sieves for Testing Purposes (ASTM Designation: E 11) of the ASTM. Square-hole woven wire cloth sieves of the following sizes will be required: No. 20 (840 micron), and No. 30 (590-micron).

(c) Testing Machine.—Any testing machine may be used which meets the following requirements: the error for loads of not less than 100 lb. shall not exceed plus or minus 1.0 percent for a new machine, or plus or minus 1.5 percent for a used machine. The testing machine shall be calibrated frequently in order to determine its accuracy.

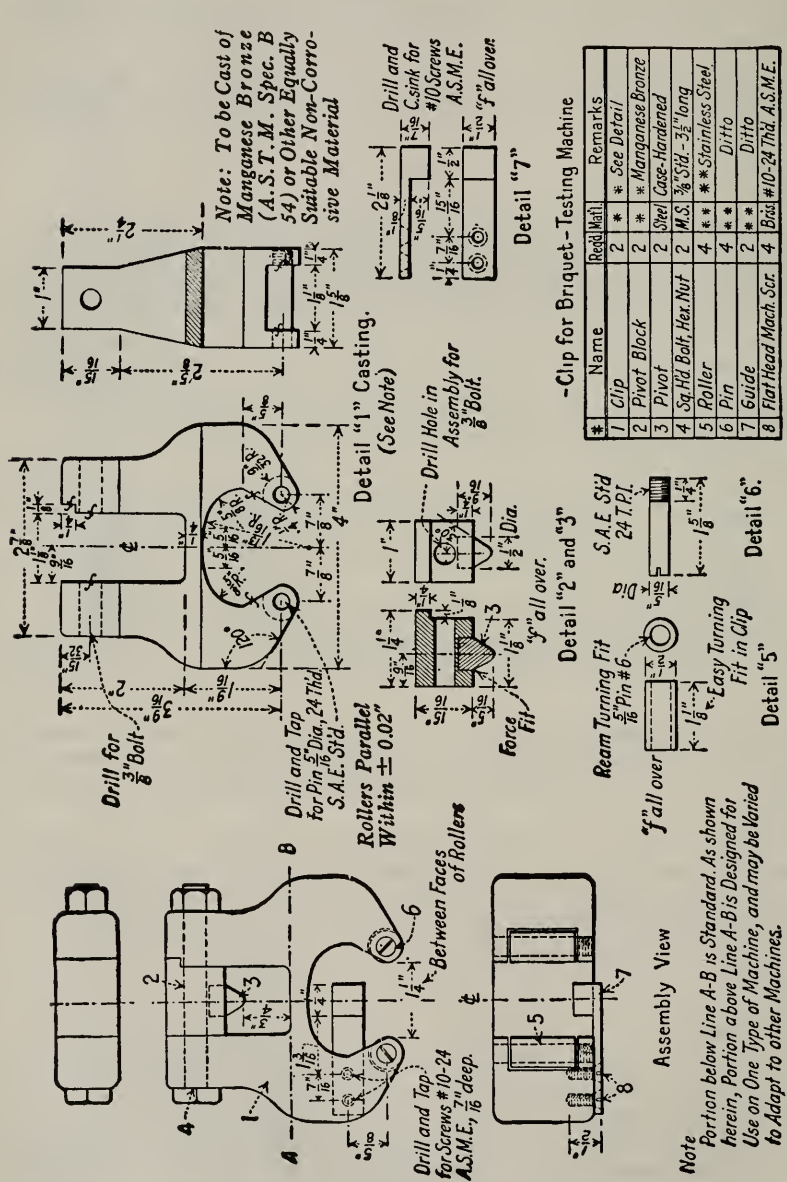
(d) Clips.—The clips for holding the tension test specimens shall be in accordance with Fig. 806.

Standard Sand

24. The sand used for making test specimens shall be natural silica sand from Ottawa, Ill., graded to pass a No. 20 (840-micron) sieve and retained on a No. 30 (590-micron) sieve. This sand shall be considered standard when not more than 15 g. are retained on the No. 20 sieve, and not more than 5 g. passes the No. 30 sieve after 5 min. of continuous sieving of a 100-g. sample in the manner specified for sieving cement on the No. 200 (74-micron) sieve (see Section 7).

Test Specimens

25. The briquet test specimen shall conform to the dimensional requirements shown in Fig. 807.



-Clip for Briquet-Testing Machine

#	Name	Req'd.	Mat'l.	Remarks
1	Clip	2	*	* See Detail
2	Pivot Block	2	*	* Manganese Bronze
3	Pivot	2	Steel	Case-Hardened
4	Sq. Hd. Bolt, Hex. Nut	2	M.S.	3/8" Std. - 3 1/2" long
5	Roller	4	**	** Stainless Steel
6	Pin	4	**	Ditto
7	Guide	2	**	Ditto
8	Flat Head Mach. Scr.	4	Brass	#10-24 Thd. A.S.M.E.

FIG. 806.—Clips for Briquet Testing Machine.

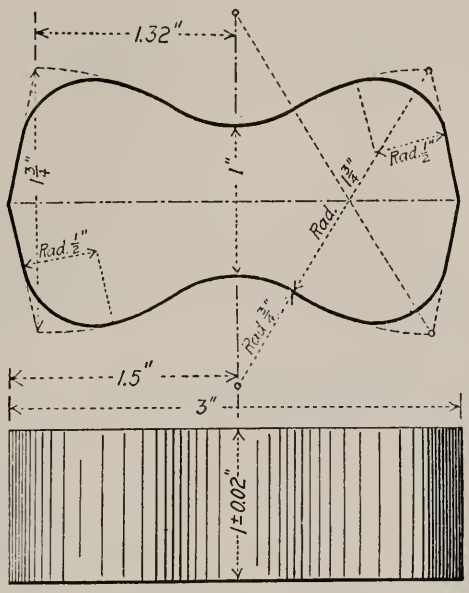


Fig. 807.—Details for Briquet.

Molding Specimens

26. The standard mortar shall be mixed in accordance with the methods for mixing cement pastes and mortars as described in Sections 8 to 10. Before being filled, the molds shall be oiled with a thin film of mineral oil. Immediately after mixing the mortar, the molds, resting on unoiled glass or metal plates, shall be filled heaping full without compacting. The mortar shall then be pressed in firmly with the thumbs, applying pressure 12 times to each briquet, at points to include the entire surface. The pressure shall be such that the simultaneous application of both thumbs will register a pressure of 15 to 20 lb. Each application of the thumbs shall be maintained not longer than sufficient to attain the specified pressure. The mortar shall then be heaped above the mold and smoothed off with a trowel. The trowel shall be drawn over the mold in such a manner as to exert a pressure of not more than 4 lb. The mold shall then be turned over upon a plane plate oiled with mineral oil, and the operation of heaping, thumbing, heaping and smoothing off repeated. No ramming or tamping shall be used, nor any troweling in excess of that required to smooth off the specimen. The thickness of the hardened briquet at the waist line upon removal from the mold shall be 1 ± 0.02 in.

Storage of Test Specimens

27. *(a)* All test specimens, immediately after molding, shall be kept in the molds on plane plates in the moist closet or moist room for from 20 to 24 hr. in such manner that the upper surfaces shall be exposed to the moist air, but protected from dripping water. The moist closet or moist room shall be so constructed as to provide storage facilities for test specimens at a relative humidity of not less than 90 percent and at a temperature of 21 ± 1.7 C.

(b) The briquet specimens shall then be removed from the molds and immersed in clean water in storage tanks constructed of noncorroding material. The storage water shall be kept clean by frequent changing. If briquets should be removed from molds before 24 hr., they should be replaced on shelves of the moist closet until expiration of the 24-hr. period.

Procedure

28. *(a)* The briquet specimens shall be tested as soon as they are removed from the moist closet for 24-hr. specimens, and from the storage water for other specimens. The bearing surfaces of the clips and briquets shall be free from sand or dirt, and the roller bearings shall be well oiled and maintained so as to insure freedom of turning. The briquets shall be carefully centered in the clips and the load applied continuously at the rate of 600 ± 25 lb. per min.

(b) Faulty Briquets.—Briquets that are manifestly faulty, or which give strengths differing by more than 15 percent from the average value of all test specimens made from the same sample and tested at the same period, shall not be considered in determining the tensile strength.

Specific Gravity

Apparatus

29. *(a)* The standard Le Chatelier flask** conforming to the dimensions shown in Fig. 808 shall be used.

(b) Kerosene free from water, or naphtha having a gravity not lighter than 62° A.P.I. shall be used in the specific gravity determination.

Procedure

30. *(a)* Specific gravity of cement shall be determined on the material as received, unless otherwise specified. If the specific gravity determination on a loss-free sample is required, the sample shall first be ignited as described in the determination for loss on ignition in Section 19 of the Standard Methods of Chemical Analysis of Portland Cement (ASTM Designation: C 114) of the ASTM.

(b) The flask shall be filled with either of the liquids specified in Section 29 *(b)* to a point on the stem between the zero and the 1-ml. mark. The inside of the flask above the level of the liquid shall be dried, if necessary, after pouring. The first reading shall be recorded after the flask has been immersed in the water bath in accordance with Paragraph *(c)*. A weighed quantity of cement (about 64 g. for portland cement) shall then be introduced in small amounts at the same temperature as the liquid (Note). Care shall be taken to avoid splashing and to see that the cement does not adhere to the inside of the flask above the liquid. A vibrating apparatus may be used to accelerate the introduction of the cement into the flask and to prevent the cement from sticking to the neck. After all the cement has been introduced, the stopper shall be placed in the flask and the flask rolled in an inclined position (Note), or gently whirled in a horizontal circle, so as to free the cement from air until no further air bubbles rise to the surface of the liquid. If a proper amount of cement has been added, the level of the liquid will be in its final position at some point of the upper series of graduations. The final reading shall be taken after the flask has been immersed in the water bath in accordance with Paragraph *(c)*.

** This apparatus has been standardized by the National Bureau of Standards. Requirements for the flask are described in "Testing of Glass Volumetric Apparatus," *Circular No. 9*, Nat. Bureau Standards, Eighth Edition, March 31, 1916.

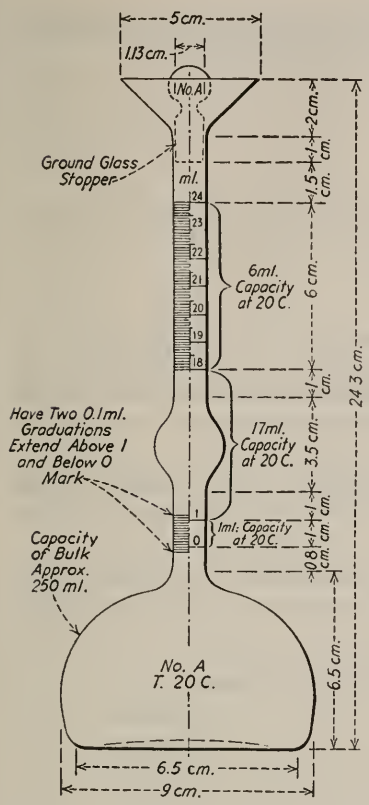


FIG. 808.—Le Chatelier Flask for Specific Gravity Test.

NOTE.—Variations of a few millimeters in such dimensions as total height of flask, diameter of base, etc., are to be expected and will not be considered sufficient cause for rejection.

(c) The flask shall be immersed in a constant temperature water bath, maintained at about room temperature, for a sufficient interval before making either of the readings so as to avoid variations greater than 0.2 C. in the temperature of the liquid in the flask. All readings shall be checked until they are constant to insure that the contents of the flask have reached the temperature of the water bath.

NOTE.—Before the cement has been added to the flask, a loose-fitting lead-ring weight around the stem of the flask will be helpful in holding the flask in an upright position in the water bath, or the flask may be held in the water bath by a burette clamp. It is advisable to use a rubber pad on the table top when filling or rolling the flask.

Calculation

31. The difference between the first and the final readings represents the volume of liquid displaced by the weight of cement used in the test. The specific gravity shall be calculated as follows:

$$\text{Sp. gr.} = \frac{\text{wt. of cement in grams}}{\text{displaced vol. in ml.}}$$

Reproducibility of Results

32. Duplicate determinations of specific gravity by this method should agree within 0.01.

TENTATIVE METHOD OF TEST FOR COMPRESSIVE STRENGTH OF PORTLAND-CEMENT MORTARS

1942

The same as ASTM Designation: C 109–37 T

Scope

1. This method of test is intended for determining the compressive strength of portland-cement mortars.

Apparatus

2. *(a) Scales.*—The scales used in weighing materials for mortar mixes shall conform to the following requirements: On scales in use the permissible variation at a load of 1500 g. shall be plus or minus 1.0 g. The permissible variation on new scales shall be one half of this value. The sensibility reciprocal* shall not be greater than twice the permissible variation.

(b) Weights.—The permissible variations on weights in use in weighing materials for mortar mixes shall be as prescribed in Table I. The permissible variations on new weights shall be one half of these values.

(c) Sieves.—The sieves shall conform to the requirements of the Standard Specifications for Sieves for Testing Purposes (ASTM Designation: E 11) of the ASTM.

Table I.—Permissible Variations on Weights

Weight, g.	*Permissible Variations, g.*
1000	±0.5
900	±0.45
750	±0.4
500	±0.35
300	±0.3
250	±0.25
200	±0.20
100	±0.15
50	±0.10
20	±0.05
10	±0.04
5	±0.03
2	±0.02
1	±0.01

Square-hole, woven wire cloth sieves of the following sizes will be required:

No. 100 (149-micron)
No. 50 (297-micron)
No. 30 (590-micron)
No. 16 (1190-micron)

* The sensibility reciprocal is a measure of the sensitiveness of a balance, and is the weight required to move the position of equilibrium of the indicating device a definite amount. For a complete definition of sensibility reciprocal, see National Bureau of Standards *Handbook*, H–22, pp. 68 and 69.

(d) Glass Graduates.—Glass graduates of 250-ml. capacities used for measuring the mixing water shall be made to deliver the indicated volume at 20 C. The permissible variation on these graduates shall be plus or minus 2 ml. The main graduation lines of the cylinders shall be circles and shall be numbered. The least graduations shall extend at least one seventh of the way around and intermediate graduations shall extend at least one fifth of the way around.

(e) Molds.—Molds for the 2-in. cube test specimens shall be tight fitting. The parts of the molds when assembled shall be positively held together. The molds shall be made of hard metal not attacked by the cement mortar. For new molds the Rockwell hardness number of the metal shall be not less than B55 (the Brinell hardness number not less than 95). There shall be sufficient material in the sides of the molds to prevent spreading or warping.

The interior faces of the molds shall be true plane surfaces with a permissible variation of 0.001 in. for new molds or 0.002 in. for molds in use.

The distances between opposite faces shall be 2 ± 0.005 in. for new molds, or 2 ± 0.01 in. for molds in use. The height of the molds, measured separately for each cube compartment, shall be 2 in. with permissible variations of plus 0.01 in. and minus 0.005 in. for new molds, or plus 0.01 in. and minus 0.015 in. for molds in use.

The angle between adjacent interior faces, and between interior faces and top and bottom planes of the mold shall be 90 ± 0.5 deg.

(f) Testing Machine.—The testing machine for determination of the compressive strength may be either the hydraulic or the screw-type with sufficient opening between the upper bearing surface and the lower bearing surface of the machine to permit the use of verifying apparatus. The load applied to the test specimen shall be indicated with an accuracy of plus or minus 1.0 percent.

The upper bearing shall be a spherically seated, hardened metal block firmly attached at the center of the upper head of the machine. The center of the sphere shall lie at the center of the surface of the block in contact with the specimen. The block shall be closely held in its spherical seat, but shall be free to turn in any direction. The diagonal or diameter** of the bearing surface shall be only slightly greater than the diagonal of the face of the 2-in. cube in order to facilitate accurate centering of the specimen. A hardened metal bearing block shall be used beneath the specimen to minimize wear of the lower platen of the machine. The bearing block surfaces intended for contact with the specimen should have a hardness not less than C60 Rockwell number (Brinell number 620). These surfaces shall not depart from plane surfaces by more than 0.0005 in. when the blocks are new and shall be maintained within a permissible variation of 0.001 in.

Temperature and Humidity

3. The temperature of the room and dry materials shall be maintained at not less than 20 C. and not more than 27.5 C. The temperature of the mixing water, moist closet or moist room, and water in the storage tank shall not vary from 21 C. by more than 1.7 C. The moist closet or moist room shall be so constructed as to provide storage facilities for test specimens at a relative humidity of not less than 90 percent.

** A diameter of 3⅛ in., which is large enough for testing 3 by 6-in. cylinders, is satisfactory provided that the lower bearing block has a diameter slightly greater than the diagonal of the face of the 2-in. cube but not more than 2.9 in., and is centered with respect to the upper bearing block and held in position by suitable means.

Graded Standard Sand

4. The sand (see Explanatory Note 1) used for making test specimens shall be natural silica sand from Ottawa, Ill., graded as follows:

Sieve	*Percentage Retained*
No. 100 (149-micron)	98 ± 2
No. 50 (297-micron)	72 ± 5
No. 30 (590-micron)	2 ± 2
No. 16 (1190-micron)	none

Sieve Analysis of Sand

5. *(a)* For checking the grading of the sand, a sieving test of the sand shall be made on each of the four sieves specified in Section 2 *(b)*. Samples of sand for the sieve tests shall be quartered from a sample of about 700 g. obtained by the method of quartering the contents of a full sack (100 lb.) which have been thoroughly mixed and the pile flattened or spread out to minimize segregation during quartering.

(b) The test on each sieve shall be made with 100 g. of sand. The sand shall be placed on the sieve which shall be thoroughly clean and dry. The sieve, with pan and cover attached, shall be held in one hand in a slightly inclined position so that the sample will be well distributed over the sieve, at the same time gently striking the side about 150 times per minute against the palm of the other hand on the up stroke. After every 25 strokes, the sieve shall be turned about one sixth of a revolution in the same direction. The operation shall be continued until not more than 0.5 g. passes through in 1 min. of continuous sieving. The weight of the residue on the sieve shall be expressed as a percentage of the weight of the original sample.

Preparing Molds

6. Molds shall be thinly covered with mineral oil. The clamped faces shall be thinly covered with a heavy mineral oil or light cup grease. After assembling the mold, excess oil or grease shall be wiped from the joints. Molds shall be set on a plane, nonabsorbent base plate which has been thinly coated with paraffin or mineral oil. A mixture of 3 parts of paraffin to 5 parts of resin by weight, heated between 110 and 120 C., shall be applied at the outside contact line of the mold and base plate so that a watertight bond is effected between the mold and the base (Note 2).

Proportioning and Mixing of Mortars

7. *(a)* The proportions of the standard mortar shall be 1 part cement to 2.77 parts graded standard sand by weight and 53 percent water by weight of cement (water-cement ratio of 0.8 by volume). The standard batch of mortar shall consist of 470 g. of cement, 1300 g. of graded standard sand, and 250 ml. of water.

(b) Mixing shall be done in a bowl (enamelware or other nonabsorbent, noncorroding material) of about 1-gal. capacity by vigorous and continuous stirring, squeezing, and kneading with one hand which shall be protected by a snug-fitting rubber glove. The materials, sufficient for making six cubes, shall be introduced in the following manner:

(1) Place the water in the bowl, which has just been wiped with a damp cloth,

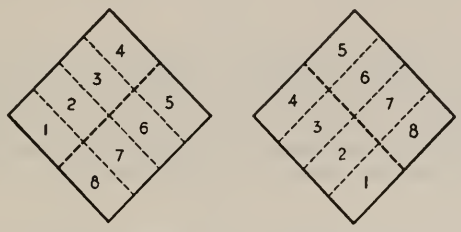
(2) Add the cement to the water and mix for 30 sec.

(3) Add approximately one half of the testing sand and mix for 30 sec., and

(4) Add the remainder of the sand and mix for 1½ min.

Molding Specimens

8. Immediately following completion of the mixing, the mortar adhering to the mixing glove shall be removed by striking the hand against the side or edge of the mixing bowl and the glove shall then be removed. A layer of mortar about 1 in. in thickness shall be placed in each of the six cubes. The mortar in each cube shall be tamped 32 times in about 10 sec. in four rounds, each round to be at right angles to the other and consisting of eight adjoining strokes over the surface of the specimen, as illustrated in Fig. 1, applying to the mortar on each stroke a pressure of about 150 g. (Note 5). The tamper shall have a cross-section of ½ by 1 in., and shall be of a convenient length (5 or 6 in.) and made of a nonabsorptive, nonabrasive material such as medium hard rubber. The four rounds of tamping (32 strokes) of the mortar shall be



Rounds 1 and 3 Rounds 2 and 4

Fig. 1.—Order of Tamping in Molding of Test Specimens.

completed in one cube before going to the next. When the tamping of the first layer in the six cubes is completed, the cubes shall be filled with the remaining mortar and again tamped as specified for the first layer. On completion of the tamping, the tops of all cubes should extend slightly above the top surface of the molds. The mortar which has been forced out onto the top surface of the mold shall be brought in with a trowel and the cubes smoothed off by drawing the flat side of the trowel once across the top of each cube at right angles to the length of the mold. The mortar shall then be cut off to a level surface flush with the top of the mold by drawing the straight edge of the trowel with a sawing motion over the length of the mold.

Storage of Test Specimens

9. Immediately after molding, the specimens shall be placed in the moist closet or moist room with their upper surfaces exposed to the moist air but protected from dripping water. Specimens shall remain in the molds for at least 20 hr.; if removed from the molds before 24 hr., they shall be kept on shelves of the moist closet or moist room until expiration of the 24-hr. period. When 24 hr. old, the specimens shall be immersed in clean water in storage tanks constructed of noncorroding materials. The storage water shall be kept clean by frequent changing.

Procedure

10. *(a)* Testing of the cube specimens shall be carried out immediately after their removal from the moist closet for 24-hr. specimens, and from storage water for all other specimens. If more than one specimen at a time is removed from the storage water for testing, these cubes shall be placed in a pan of water of sufficient depth to completely immerse each cube until its removal for testing. The load shall be applied to the faces

of the cubes that were in contact with the true plane surfaces of the mold. These faces shall be checked by application of an accurate straight edge (Note 3). If appreciable curvature is present, the face or faces shall be ground to a plane surface before loading, or the specimens shall be discarded.

(b) Loose sand grains or incrustations shall be removed from the contact faces and the cubes shall then be carefully placed in the testing machine below the center of the upper bearing block. No cushioning or bedding materials shall be used. The loading up to 50 percent (25 percent for expected maximum loads of less than 4,000 lb. at ages of 7 days or less) of the expected maximum load may be applied at any convenient rate, after which the specimens shall be loaded continuously to failure at a rate or rates which shall at no time be less than 1,000 nor more than 6,000 psi. per min.†

Calculation

11. The total maximum load indicated by the testing machine shall be recorded, and the compressive strength calculated in pounds per square inch from the cross-sectional area of the cube tested (Note 4). Cubes that are manifestly faulty or that give strengths differing by more than 10 percent from the average value of all test specimens made from the same sample and tested at the same period shall not be considered in determining the compressive strength (Note 5).

Explanatory Notes

Note 1: *Segregation of Graded Sand.*—The graded standard sand should be handled in such a manner as to prevent segregation, since variations in the grading of the sand cause variations in the consistency of the mortar. It is recommended that each sack of sand be emptied when delivered to the laboratory for use and its contents mixed by means of a shovel or scoop. The sand may then be resacked, if desired, and scooped directly from the sack as needed in testing. In both of these operations care should be taken to prevent segregation. In emptying sacks of sand into bins or in scooping it out of bins, care should be exercised to prevent the formation of mounds of sand or craters in the sand, down the slopes of which the coarser particles will roll. Bins should be of sufficient size to permit the above precautions. Devices for drawing the sand from bins by gravity should not be used.

Note 2: *Watertight Molds.*—The mixture of paraffin and resin specified for sealing the joint between mold and base plate may be found difficult to remove when molds are being cleaned. A watertight joint may be secured with paraffin alone by slightly warming the mold and base plate before brushing the joint. Molds so treated should be allowed to return to room temperature before use. Use of straight paraffin is permissible *if a watertight joint is secured.*

Note 3: *Cube Faces.*—Results much lower than the true strength will be obtained by loading faces of the cube which are not truly plane surfaces. Therefore, it is essential that cube molds be kept scrupulously clean, as otherwise large irregularities in the surfaces will occur. Instruments for cleaning of molds should always be softer than the metal in the molds to prevent wear. In case grinding of cube faces is necessary, it can be accomplished best by rubbing the cube on a sheet of fine emery paper or cloth glued to a plane surface, using only a moderate pressure. Such grinding is tedious for more than a few thousandths of an inch; where more than this is found necessary, it is recommended that the cube be discarded.

Note 4: *Calculation of Strength.*—Ordinarily, the cross-sectional area of the cube tested may be assumed to be 4.00 sq. in.; however, in cases where the area of the cube varies more than 0.06 sq. in. from 4.00 sq. in., the actual area shall be used for calculation of the compressive strength.

† While the data presented in the report of the 1933 cooperative tests (see the Report of Working Committee on Plastic Mortar Tests for Portland Cement, of Committee C–1 on Cement, *Proceedings,* ASTM, Vol. 34, Part I, p. 322 (1934) do not give conclusive evidence on effect of rate of loading. the Working Committee favors the use of a uniform rate of loading of about 4000 psi. per min. (1000 psi. per min. for low-heat portland cement at ages of 7 days or less).

NOTE 5: *Faulty Cubes.*—Faulty cubes may result from occlusions of air during molding unless care is exercised. All indentations resulting from the puddling of the lower layer of mortar should be smoothed out before introducing the top layer. Excess puddling, resulting in segregation of the materials, should be avoided. In testing, cubes should be loaded to destruction and after rupture their centers examined for air pockets. Improper centering of cubes resulting in oblique fractures or lateral movement of one of the heads of the machine during loading will often cause lower strength results. Cubes so broken shall be considered as "manifestly faulty" unless their strengths agree within reasonable limits with those of cubes exhibiting a normal pyramidal fracture.

TENTATIVE METHOD OF TEST FOR FINENESS OF PORTLAND CEMENT BY MEANS OF THE TURBIDIMETER

1942

The same as ASTM Designation: C 115–41 T

Scope

1. This method of test covers the Wagner turbidimeter apparatus and procedure for determining the fineness of portland cement as represented by specific surface expressed as total surface area in square centimeters per gram of cement.

APPARATUS

Nature of Apparatus

2. The Wagner turbidimeter consists essentially of a source of light of constant intensity adjusted so that approximately parallel rays of light pass through a suspension of the cement to be tested and impinge upon the sensitive plate of a photoelectric cell. The current generated by the cell is measured with a microammeter and the indicated reading is a measure of the turbidity of the suspension. General considerations indicate that turbidity is in turn a measure of the surface area of the suspended sample of cement. The apparatus, illustrated in Fig. 1, shall consist specifically of the parts described in Sections 3 to 9.

Turbidimeter

3. The turbidimeter shall be mounted in a suitable case and shall include the following features:

(a) Source of Light.—The source of light (Fig. 1) shall consist of a 3 to 6 candle-power, concentrated filament electric lamp operated by a 6-v. storage battery, or a source of constant emf. A parabolic reflector shall be mounted behind the lamp and the lamp focused in such manner that approximately parallel rays of light will pass through the sedimentation tank and will impinge upon the photoelectric cell. The light intensity shall be regulated by means of two rheostats having resistances of approximately 6 and 30 ohms, respectively, and mounted in series with the lamp but in parallel with each other.

(b) Water Cell.—The light shall pass through a water cell before entering the sedimentation tank in order that radiant heat from the beam shall be absorbed. The cell shall consist of 3-in. diameter brass tubing, 4 in. in length with glass windows cemented in the ends with a suitable sealing material. A stoppered hole shall provide for filling with distilled water. The cell shall be so arranged that all rays of light entering the sedimentation tank shall first pass through the water.

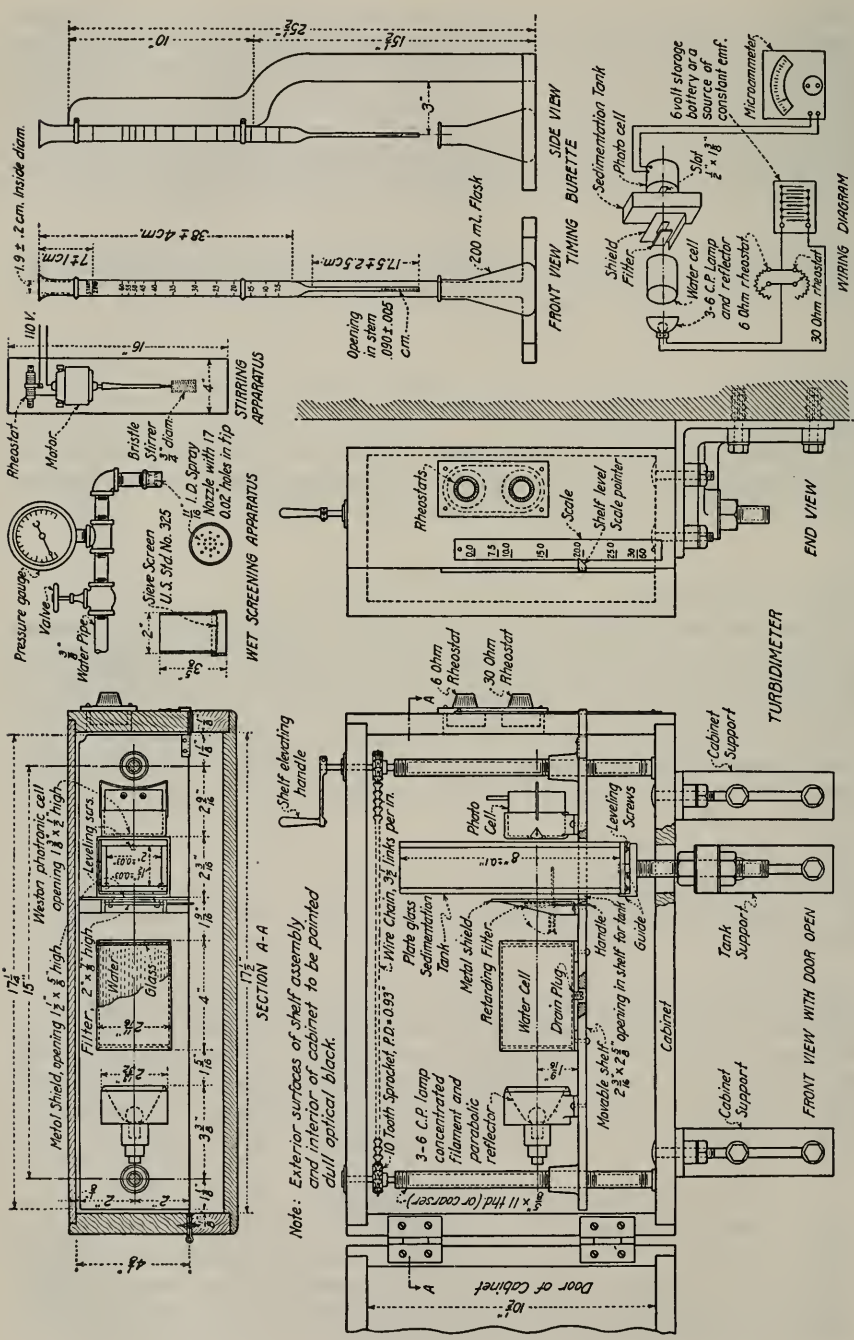


Fig. 1.—Dimensional Details of Turbidimeter Fineness Test Apparatus.

(c) Retarding Filter.—A light-retarding glass or other device shall be provided which will reduce the intensity of light from that corresponding to 100 microamperes to a reading of 20 to 30 microamperes. The light intensity shall be uniformly retarded over the entire area of that portion of the cell which is exposed to light during a test.

(d) Sedimentation Tank.—The sedimentation tank shall be constructed of $\frac{3}{16}$-in. plate glass cemented together to form a rectangular tank having inside dimensions 2 by 1½ in. by 8 in. in height. The permissible variations on the inside dimensions of the tank shall be plus or minus 0.03 in. in length and width and plus or minus 0.1 in. in height. The 2-in. faces of the tank shall be placed normal to the beam of light, and shall be equidistant within 0.01 in. at all points. A mark shall be placed on the side of the tank to indicate a volumetric content of 335 ml., which is the level to which the tank will be filled in a test.

(e) Photoelectric Cell.—The means of measuring the light intensity shall be a sensitive photoelectric cell (Weston Photronic type) connected directly to a microammeter. A hood with a horizontal slot ½ in. in height by 1⅜ in. in width shall be mounted over the face of the photoelectric cell.

(f) Shield.—A metallic shield having a slot ⅝-in. in height by 1½ in. in width, as indicated in Fig. 1, shall be placed between the water cell and the sedimentation tank.

(g) Elevating Device.—The source of light, water cell, photoelectric cell, retarding filter, and shield shall be mounted on a movable shelf which may be raised or lowered, and which may be readily and accurately adjusted so that the turbidity of the suspension may be determined at any desired depth. The sedimentation tank shall be mounted on a base which is independent of the rest of the apparatus so that the tank shall be free from vibration caused by moving the shelf. The level of the light beam with reference to the surface of the suspension shall be indicated by a pointer which will travel along a scale mounted on the cabinet. The zero of the scale shall indicate that position at which the center lines of the slots for the light beam are at the same elevation as the surface of the liquid in the tank when filled to the 335-ml. level. The lines on the scale to be marked 7.5, 10, 15, 20, 25, and 30–60, shall be located at distances from the zero mark equal to values "*h*" in Table I, and shall indicate the positions at which the pointer

TABLE I.—VALUES OF h, d, AND $\frac{h}{d^2}$ TO BE USED IN CALIBRATION OF THE TURBIDIMETER APPARATUS

Particle Diameter, d, microns	*Depth of Suspension, h, cm.*	$\frac{h}{d^2}$
60	15	0.00417
55	15	0.00496
50	15	0.00600
45	15	0.00741
40	15	0.00938
35	15	0.01225
30	15	0.01667
25	13.1	0.0210
20	10.0	0.0250
15	6.6	0.0293
10	3.3	0.0333
7.5	2.1	0.0375

should be located when turbidity readings for these particle sizes are taken. The interior of the turbidimeter cabinet and the exterior surfaces of the shelf, parabolic reflector, water cell, shield, and photoelectric cell hood shall be painted with a dull optical black paint.

Microammeter

4. The microammeter shall have a range of 0 to 50 microamperes, shall be readable to 0.1 microampere, and accurate to 0.25 microampere. The internal resistance of the microammeter shall be between 50 and 150 ohms.

Source of Current

5. A 6-v. automobile starting and lighting storage battery or a source of constant emf. shall be used for supplying current to the lamp.

Sieve

6. The sieve shall be 2 in. in diameter and have side walls 3 in. in height, and shall be fitted with a No. 325 (44-micron) woven wire screen cloth, which cloth shall conform to the requirements of the Standard Specifications for Sieves for Testing Purposes (ASTM Designation: E 11) of the ASTM, and be such that the sieve correction factor obtained shall not be greater than 15 percent (see Section 10 *(b)*).

Stirring Apparatus

7. The stirring apparatus shall consist of either *(a)* a cylindrical brush, ¾ in. in diameter and about 1¾ in. in length, with an end approximately fitting the contour of the bottom of a ⅞-in. diameter test tube, or *(b)* any other stirring device which will be equally efficient in dispersion as measured by specific surface determinations on a standard sample. The stirring apparatus shall rotate at a speed of approximately 3,500 rpm.

Timing Burette

8. The time of settling for the different sized particles shall be obtained from a burette from which kerosene is allowed to flow. The burette shall consist of a glass tube having a capillary tube fused into the lower end. The upper end of the large tube shall be flared to serve as a funnel for introducing kerosene into the tube. The burette shall conform to the following limiting dimensions:*

	Dimension, cm.	*Permissible Variation, cm.*
Length of large tube	38	± 4
Inside diameter of large tube	1.9	± 0.2
Length of capillary	17.5	± 2.5
Diameter of capillary	0.09	± 0.005
Top of burette to zero line	7	± 1

Suspending Liquid

9. Clear white kerosene shall be used with the turbidimeter apparatus.

* Since glass tubing of desired dimensions is not always obtainable, the above wide permissible variations allow selection of dimensions to produce a burette having a duration of flow which will permit of calibration as described in Section 10 *(a)*.

Calibration of Apparatus

Calibration of Turbidimeter

10. The turbidimeter apparatus shall be calibrated in accordance with the following procedure:

(a) Calibration of Burette Scale.—For calibration of the burette scale a kerosene having a known viscosity and density for the temperature at which the calibration is to be made shall be used. The times of flow from the burette which correspond to the times of settling for the different sized particles shall be calculated from the following equation:

$$t = \frac{1{,}837{,}000u}{(P_1 - P_2)} \times \frac{h}{d^2}$$

where:

t = time of settling, or time of flow in seconds,
u = viscosity of kerosene in poises,
P_1 = density of cement particles in grams per cubic centimeter = 3.15 for portland cement,[a]
P_2 = density of kerosene in grams per cubic centimeter,
h = depth of suspension to level of light in centimeters, and
d = diameter of particle in microns.

Values of $\frac{h}{d^2}$ are given in Table I.

The burette shall next be filled with kerosene at the calibrating temperature, a timing clock shall be started at the instant the kerosene in the burette drains past the zero line, and levels reached by the draining kerosene shall be marked on the burette for each of the time intervals, t, calculated as described above. At these marks, permanent lines and numbers indicating the corresponding diameters shall be etched on the burette (Note).

The construction and graduation of the burette shall be such that the time required for the kerosene to pass the permanent lines of the burette shall agree with the calculated time of settling within 1 percent, except that the permissible variation shall be not less than 1 sec.

Note.—By using the calibrated burette the apparatus may be used within the normal range of room temperatures without further correction, the change in rate of flow of the kerosene from the burette automatically compensating for change in viscosity of the suspension due to temperature. The kerosene in the burette and that of the suspension should be kept the same within 1 F. (0.5 C.). This condition will ordinarily exist if the supply of kerosene is kept in the same room as the apparatus.

Extreme care must be taken to ascertain that only clean kerosene is used in the burette, and in addition the capillary should be examined frequently to make sure that no small pieces of lint or other foreign material have become lodged in it.

(b) Calibration of No. 325 Sieve.—The spray nozzle and pressure gage shall be connected to a water supply line and the pressure on the spray nozzle adjusted to 10 psi. One gram of the current lot of National Bureau of Standards' Standard Sample No. 114[2] shall be placed on the No. 325 (44-micron) sieve and washed for 1 min. The sieve and residue shall be dried in an oven or over a hot plate (Note 1) and the residue brushed from the sieve and weighed on an analytical balance. The difference between the amount of residue obtained in this manner and the amount of residue indicated by

[a] The specific gravity of portland cement does not vary greatly, and in this work it is considered constant at 3.15. A variation of 0.15 from this value when substituted in Stokes' law gives a variation of 2.5 percent in the diameter of the particle measured.

the fineness specified for the standard sample, expressed as a percentage of the former residue, shall be the sieve correction factor (see Note 2; also Table II, footnote *a*).

NOTE 1.—Care should be taken not to heat the sieve hot enough to soften the solder.

NOTE 2.—It should be observed that the sieve correction as specified is a *factor* to be *multiplied* by the residue obtained and that the amount to be added to or subtracted from the residue in any given test is therefore proportional to the amount of residue.

(c) Determination of the Proper Light Intensity, I_0.—The calibration of the turbidimeter proper shall be made by adjustment of the light intensity, I_0. Increasing the light intensity reduces the calculated surface area of any sample and *vice versa*. Using the regular test procedure described in Sections 12 to 14, and with the light adjusted to a trial value of 25 microamperes through the filter, a determination of the specific surface shall be made using the current lot of National Bureau of Standards' Standard Sample No. 114.[2] If a specific surface greater than that assigned for the standard sample is obtained, the light intensity through the filter shall be increased, the suspension shall be reagitated, and the analysis repeated. If a specific surface less than the assigned value is obtained, the light intensity shall be decreased, the suspension reagitated, and the analysis repeated. Using new suspensions, the above procedure shall be repeated twice and the average of the three intensities noted. When the intensity is found which results in a specific surface within plus or minus 15 sq. cm. of the values assigned to the standard sample, the tank shall be removed and the intensity through the filter recorded. The light shall next be adjusted to this average value and a tank of clear kerosene placed in its path. The intensity through the filter plus tank of clear kerosene shall be recorded. This becomes the permanent reference value for the intensity of the light, and the rheostats shall be adjusted at the beginning of each test to give this value through the filter plus tank of clear kerosene from the regular supply.

TEST SAMPLE

Size of Test Sample

11. The size of the sample of cement for test shall be so selected that the microammeter readings will occur in the middle portion of the microammeter scale (Note).

NOTE.—The following approximations will be helpful in many instances in selecting the size of sample: 0.3-g. sample for a cement of which more than 85 percent passes a No. 325 (44-micron) sieve, 0.4-g. sample for a cement of which 70 to 85 percent passes a No. 325 sieve, and 0.5-g. sample for a cement of which less than 70 percent passes a No. 325 sieve.

PROCEDURE

Sieve Determination

12. A No. 325 (44-micron) sieve determination shall be made on a 1-g. sample of the cement in accordance with the procedure specified for calibration in Section 10 *(b)*. The percentage (corrected) of cement passing the sieve shall be recorded as *r*. (See Note; also Table II, footnote *a*.)

NOTE.—After three determinations the sieve should be dipped in diluted HCl (1:10) and immediately rinsed with water to remove particles lodged in the meshes. After 25 determinations the sieve should be recalibrated.

Preparation of the Suspension

13. *(a)* The cement sample shall be placed in a test tube with 10 to 15 ml. of kerosene and 5 drops of oleic acid (U.S.P.) (Oleic acid is added as a dispersing agent and

[2] Obtainable at the National Bureau of Standards, Washington, D. C.

has slight or no effect on the viscosity of the kerosene. The oleic acid, which changes with age and exposure to heat and light, should be kept in a well-stoppered dark-glass bottle.) The mixture shall then be stirred for 1 min. with the apparatus described in Section 7 and shall then be transferred to the settling tank, the brush and tube washed with clear kerosene which shall also be added to the suspension, and clear kerosene added until the total volume of the suspension in the tank is 335 ml. (Note).

NOTE.—Since it is important that the level of the liquid in the tank coincide with the zero mark on the scale of the instrument (see Section 3 *(g)*), it is correspondingly important that the volume of the suspension be close to 335 ml., as specified. This may be accomplished by the use of a flask, calibrated to deliver 335 ml., from which all the kerosene used in making up a suspension is taken; or a point gage may be used, consisting essentially of a flat plate approximately 2 by 2½ in. to the center of which is attached vertically a metal pin of such length that, when the plate is placed in position on top of the tank, the point of the pin is at the 335-ml. level. Either of these methods should insure the position of the liquid level within a few tenths of a millimeter.

(b) Agitation of the Suspension.—Just before being placed in the path of the light beam, the tank shall be agitated to effect a uniformity of the suspension. The tank shall be covered with a ground-glass cover and oscillated 180 deg. about a horizontal axis, turning the tank upside down and back again to its original upright position approximately once each second for about 1 min. (Note 1). Care should be taken to prevent loss of kerosene (Note 2). The suspension will then be ready to place in its proper position in the path of the light beam.

NOTE 1.—The procedure described for oscillating the suspension must be carefully followed. The procedure used in shaking a cocktail must not be used.

NOTE 2.—The faces of the glass tank shall be clean when the suspension is added, and care must be taken to avoid as much as possible the necessity of cleaning the faces thereafter.

Procedure

14. The turbidimeter apparatus shall be operated in accordance with the procedure described in the following Paragraphs *(a)* to *(h)*:

(a) With retarding filter and sedimentation tank containing approximately 100 ml. of clear kerosene in the light path, the light shall be adjusted to the proper intensity, I_0, by taking repeated readings at 1-min. intervals until an unchanging value shall indicate that the lamp and photoelectric cell are in equilibrium (Note).

NOTE.—To protect the microammeter, the lamp must never be turned on without a suspension or the retarding filter in position to reduce the light intensity to a value within the range of the microammeter.

(b) The proper size of sample of cement (Section 11) shall be weighed and a suspension prepared in accordance with Section 13.

(c) The shelf level pointer shall be placed at the 30–60-micron position.

(d) The burette shall be filled to a suitable height with kerosene from the same lot and at the same temperature as the kerosene used in the suspension, and oscillation of the tank containing the suspension shall be started in accordance with Section 13 *(b)*. The oscillation shall be continued until the kerosene drains to the zero line on the burette, when the agitation shall be stopped (Note). The tank shall be immediately placed in position in the path of the light beam.

NOTE.—The lid to the tank must fit so that no kerosene drains down the outside faces of the tank.

(e) The retarding filter shall be immediately removed from the light path and the cabinet door closed.

(f) The microammeter shall be read at the instants the kerosene in the burette drains past marks 60, 55, 50, 45, 40, 35, and 30.

(g) The shelf shall then be raised successively to the marks 25, 20, 15, 10, and 7.5 on the pointer scale, the microammeter being read at each position as the kerosene drains past the corresponding mark on the burette.

(h) The filter shall be replaced in the path of the light beam, the tank removed, and the intensity of the lamp checked (Note).

NOTE.—If the microammeter indication has shifted more than 0.3 microampere from the initial setting through the filter alone, the test must be repeated. A freshly charged storage battery should be momentarily short-circuited to reduce the voltage to constant value. If the microammeter indication continues to fluctuate, look for loose connections in the lamp and photo-electric-cell circuits, see that the rheostate contacts are clean, and make certain that the lamp, socket, and reflector are rigidly fixed in their mounting.

CALCULATION

Calculation and Record

15. *(a) Specific Surface.*—Specific surface shall be calculated from the following equation:

$$S = \frac{38r(2 - \log I_{60})}{1.5 + 0.75 \log I_{7.5} + \log I_{10} + \log I_{15} + \log I_{20} \ldots + \log I_{55} - 11.5 \log I_{60}}$$

where:

S = specific surface of the sample in square centimeters per gram,
r = corrected percentage by weight passing the No. 325 (44-micron) sieve, and
$I_{7.5}, I_{10}, I_{15} \ldots I_{60}$ = microammeter readings, in microamperes, which correspond to the particle diameters 7.5, 10, 15 . . . 60 microns.

NOTE.—The constant factor 38 applies only to a material having the specific gravity of portland cement (approximately 3.15). For any other material there must be calculated the corresponding proper value for this factor which, in the derivation of the formula, varies inversely as the density of the particles (in grams per cubic centimeter).

(b) Recording of Data.—The form shown in Table II is suggested for the recording of turbidimeter data and calculation of specific surface.

Calculation of Specific Surface from First Turbidity Reading I_{60}

16. *(a)* This method may be used for successive determinations from the same plant, provided, that the same size test samples are used, and that there is no great change in fineness, color, or other properties of the cement. Under these conditions the specific surface of a sample may be calculated from the first turbidity reading, I_{60}, by using the following equation:

$$S = c(2 - \log I_{60})$$

where:

S = specific surface of the sample in square centimeters per gram,
I_{60} = microammeter reading corresponding to particle diameter of 60 microns, and
c = transmittancy constant for the particular plant.

NOTE.—The transmittancy constant "c" may be evaluated by substituting in the above equation known values of S and $2 - \log I_{60}$ as determined from a complete turbidimeter test. The average of not less than five values of "c," as determined from complete tests, should be used in the above equation.

(b) If the fineness of a sample as determined in accordance with Paragraph *(a)* fails to conform to the specification requirements for fineness, a retest shall be made by the complete procedure described in Sections 14 and 15.

TABLE II.—ILLUSTRATIVE FORM FOR RECORDING TURBIDIMETER TEST DATA AND CALCULATION OF SPECIFIC SURFACE

(Values shown are for purposes of illustration only.)

Sample Identification ..... Sample X
Passing No. 325 (44-micron) Sieve (wet method), r, corrected ..... 89.7 percent[a]
Filter Reference (through filter alone)
Before Test ..... 20.5 microamperes
After Test ..... 20.5 microamperes
Weight of Sample Tested ..... 0.3 g.

Particle Size, Microns	*I, Microamperes*	*Log I*	
60	11.0	.....	1.041[b]
55	11.1	1.045	
50	11.3	1.053	
45	11.5	1.061	
40	11.7	1.068	
35	12.1	1.083	
30	12.6	1.100	
25	13.4	1.127	
20	14.4	1.158	
15	15.7	1.196	
10	19.1	1.281	
7.5	23.0	.....	1.362[b]
	0.75 × 1.362 =	1.022	
		1.500	
	Sum =	13.694	
	11.5 × 1.041 =	11.972	
	Difference =	1.722	

$$S = \frac{38 \times 89.7 \times 0.959}{1.722} = 1900 \text{ sq. cm. per g.}$$

Determination:

Residue specified for standard sample No. 114c = 10.8 percent, or a residue for 1-g. test sample = 0.108 g.
Residue obtained on the sieve, which is being calibrated with standard sample = 0.100 g.

Difference between specified and test residues = 0.008 g.

Correction factor for sieve (plus in this example) $= +\frac{0.008}{0.100} \times 100 = +8.0$ percent

Application:

Sieve correction factor = + 8.0 percent
Residue from the sample under test = 0.095 g.
Correction = + 0.08 × 0.095 g. = +0.008 g.

Corrected residue (algebraic sum) = 0.103 g. = 10.3 percent
Corrected amount passing sieve (r) = 89.7 percent

[a] The following example presents an illustration of the determination and application of the sieve correction factor for a No. 325 sieve (wet method):

[b] For convenience in calculation, log I_{60} and log $I_{7.5}$ are recorded in a separate column.

TENTATIVE METHOD OF TEST FOR AUTOCLAVE EXPANSION OF PORTLAND CEMENT

1942

The same as ASTM Designation: C 151–40 T

Scope

1. This method of test is intended for determining the soundness of portland cement by means of an autoclave test on a 1 by 1-in. neat-cement specimen.

Apparatus

2. *(a) Scales.*—The scales and weights used for weighing materials shall conform to the requirements prescribed in Section 8 *(a)* and *(b)* of the Standard Methods of Sampling and Physical Testing of Portland Cement (ASTM Designation: C 77) of the ASTM.

(b) Glass Graduates.—Glass graduates of 150-ml. capacity used for measuring the mixing water shall be made to deliver the indicated volume at 20 C. (68 F.). The permissible variation on these graduates shall be plus or minus 1 ml. The main graduation lines of the cylinders shall be circles and shall be numbered. The least graduations shall extend at least one seventh of the way around, and intermediate graduations shall extend at least one fifth of the way around the cylinder.

(c) Molds.—Molds shall provide for 1 by 1-in. test specimens of 10-in. effective gage length. The effective gage length shall be considered as that length between the innermost points of the metal inserts used as reference points. The parts of the molds shall be tight fitting and firmly held together when assembled. The molds shall be made of steel or hard metal not readily attacked by the cement paste. There shall be sufficient material in the sides of the molds to prevent spreading or warping. Each end plate of the molds shall be equipped to hold properly in place, during the setting period, a stainless steel or noncorroding metal reference point having a diameter of ¼ in. The reference points shall be set so that their principal axes coincide with the principal axis of the test specimen, and shall extend into the specimen ⅝ in. The distance between the inner ends of the reference points shall be 10 ± 0.1 in. The distance between opposite faces of the molds shall be 1 ± 0.03 in. The height of the molds, measured separately for each specimen compartment, shall be 1 ± 0.03 in., both for new molds and for molds in use.

(d) Autoclave.—The autoclave shall consist of a high-pressure steam boiler equipped with an automatic pressure control and a safety valve. The capacity of the heating unit shall be such that with maximum load (water plus specimens) the pressure of the saturated steam in the autoclave may be raised to a gage pressure of 295 psi. (absolute pressure about 310 psi.) in 1 to 1¼ hr. from the time the heat is turned on. The automatic pressure control shall be capable of maintaining the pressure at 295 ± 5 psi. for at least 3 hr. A gage pressure of 295 ± 5 psi. corresponds to a temperature of 215.7 ± 1 C. (420.3 ± 2 F.). The autoclave shall be designed to permit the pressure to drop from 295 psi. to less than 10 psi. in 1 hr. after the heat supply has been shut off. It shall be equipped with a vent valve for allowing the escape of air during the early part of the heating period and for releasing any steam pressure remaining at the end of the 1-hr. cooling period.

(e) Length Comparator.—Changes in length of the test specimen shall be measured by a dial gage or micrometer comparator having a range of at least 0.3 in. The instrument shall be graduated to 0.0001 in., and when tested at any point throughout its range, the error shall not be greater than plus or minus 0.0004 in. The difference be-

tween repeated measurements shall not be greater than 0.0001 in. The comparator shall be equipped with a steel reference bar and shall be frequently checked with this reference bar.

Temperature and Humidity

3. *(a)* The temperature of the molding room and dry materials shall be maintained at not less than 20 C. (68 F.) and not more than 27.5 C. (81.5 F.). The temperature of the mixing water and of the moist closet or moist room shall not vary from 21 C. (70 F.) by more than 1.7 C. (3 F.).

(b) The moist closet or moist room shall be so constructed as to provide storage facilities for test specimens at a relative humidity of not less than 90 percent.

Preparation of Test Specimens

4. *(a) Preparation of Molds.*—Molds shall be thinly covered with mineral oil; after this operation the stainless steel or noncorroding metal reference points shall be set, care being taken to keep them clean and free of oil.

(b) Mixing Cement Paste.—The standard batch shall consist of 500 g. of cement with sufficient water to give a paste of normal consistency, and shall be mixed in accordance with the procedure described in Section 10 of the Standard Methods of Sampling and Physical Testing of Portland Cement (ASTM Designation: C 77) of the ASTM.

(c) Molding Specimens.—Immediately following completion of mixing, the test specimen shall be molded in one or two layers, each layer being compacted with the thumbs or forefingers by pressing the paste into the corners, around the reference inserts, and along the surfaces of the molds until a homogeneous specimen is obtained. After the top layer has been compacted, the paste shall be cut off flush with the top of the mold and the surface smoothed with a few strokes of the trowel. During the operations of mixing and molding, the hands shall be protected by rubber gloves.

(d) Storage of Test Specimens.—After the mold has been filled, it shall be immediately placed in the moist closet or moist room. Specimens shall remain in the molds in the moist closet or moist room for at least 20 hr.; if removed from the molds before 24 hr., they shall be kept in the moist closet or moist room until tested.

Procedure

5. *(a)* At 24 hr. ± 30 min. after molding, the specimens shall be removed from the moist atmosphere, measured for length, and placed in the autoclave at room temperature in a rack so that the four sides of each specimen will be exposed to saturated steam. The autoclave shall contain enough water to maintain an atmosphere of saturated steam vapor during the entire period of test. Ordinarily, 7 to 10 percent of the volume of the autoclave should be occupied by the water.

(b) To permit air to escape from the autoclave during the early portion of the heating period, the vent valve shall be left open until steam begins to escape. The valve shall then be closed and the temperature of the autoclave shall be raised at such a rate as will bring the gage pressure of the steam to 295 psi. in 1 to 1¼ hr. from the time the heat is turned on. The 295 ± 5 psi. pressure shall be maintained for 3 hr. At the end of the 3-hr. period the heat supply shall be shut off and the autoclave cooled at a rate such that the pressure will be less than 10 psi. at the end of 1 hr., and any pressure remaining shall be slowly released by partially opening the vent valve until atmospheric pressure is attained. The autoclave shall then be opened and the test specimens imme-

diately placed in water the temperature of which is above 90 C. (194 F.). The water surrounding the bars shall then be cooled at a uniform rate by adding cold water so that the temperature of the water will be lowered to 21 C. (70 F.) in 15 min. The water surrounding the specimens shall then be maintained at 21 C. (70 F.) for an additional 15 min., when the specimens shall be surface dried and their lengths again measured.*

Calculation

6. The difference in length of the test specimen before and after autoclaving shall be calculated to the nearest 0.01 percent of the effective gage length and shall be reported as the autoclave expansion of the cement. A contraction (negative expansion) shall be indicated by prefixing a minus sign to the percentage expansion reported.

Retests

7. Cement failing to meet the test for soundness in the autoclave may be accepted if it passes a retest, using a new sample, at any time within 28 days thereafter. The provisional acceptance of the cement at the mill shall not deprive the purchaser of the right of rejection on a retest of soundness and time of setting at the time of delivery of the cement to the purchaser.

Report on Assignment 2 (b)

Specifications and Principles of Design of Plain and Reinforced Concrete for Use in Railway Bridges, Buildings and Culverts

Concrete Bridge Deck Slabs of the Non-Ballast Type, Collaborating with Committee 5—Track

A. N. Laird (chairman, subcommittee), G. H. Dayett, Theodore Doll, Meyer Hirschthal, J. E. Kalinka, J. L. Rippey, C. P. Schantz, F. R. Smith, L. I. Stone, E. O. Sweetser, Jamison Vawter, H. J. Voelker, W. R. Wilson.

This report is submitted as information, with the recommendation that the assignment be temporarily discontinued.

The committee has carefully reviewed the subject matter previously submitted as information in Volume 41, pages 356 to 363 inclusive, and has kept in touch with recent construction of this type. One type not included in the previous report consists of stub or full cross ties embedded in the deck concrete similar to the floor design shown on Supplement to Figures 835 and 836 for Tunnels with Concrete Lining on page 8–104.1 of the Manual. This type has been used extensively in tunnel and terminal construction with satisfactory results.

The committee believes that there has been insufficient experience with the various designs to enable it to make recommendations in specification form at this time.

* If it is preferred to make all measurements at 26.5 C. (80 F.), it is recommended that upon removal of the specimens from the moist closet or moist room, they be placed in water maintained at 26.5 C. (80 F.) for at least 15 min., removed and measured for length, and then placed in the autoclave. Upon removal from the autoclave, the specimens and water shall be cooled to 26.5 C. (80 F.) in 15 min. and the specimens kept in water at this temperature for an additional 15 min., and then measured for length.

Report on Assignment 3

Progress in the Science and Art of Concrete Manufacture

C. P. Marsh (chairman, subcommittee), H. E. Burr, Maurice Coburn, F. W. Capp, R. Hayes, A. C. Irwin, J. E. Kalinka, W. M. Ray, F. B. Robins, G. E. Shaw, F. R. Smith, H. J. Voelker, L. W. Walter.

In its report of last year, which was printed in Bulletin No. 422, pages 305–307, your committee discussed the properties and uses of the five types of portland cement covered by new specifications of the ASTM.

After some minor changes these specifications have been adopted by the ASTM during the past year, as a "Standard" specification and have been issued under the ASTM serial designation C 150–41.

As will be noted under Assignment 1. Revision of the Manual, your committee has recommended that these new specifications, together with certain methods and sampling and testing referred to therein, be adopted to replace the corresponding material now in the Manual.

Your committee desires to call attention to the following differences between these new specifications and those now in the current Manual.

(a) *Types.*—The new specifications cover five types of cement as compared with the two types in the present specifications.

(b) *Chemical Limits.*—In addition to the four requirements contained in the present specifications, the new specifications place a limit on the tricalcium aluminate content in the Type III or High-Early-Strength cement. The new specifications contain requirements for silicon dioxide, aluminum oxide, ferric oxide, ratio of AL_2O_3 to Fe_2O_3, tricalcium silicate, dicalcium silicate and tricalcium aluminate, which are not contained in the present specifications.

(c) *Strength.*—The present Specifications for High-Early-Strength Portland Cement contain an optional compressive strength test. The new specifications contain requirements for both tensile strength and compressive strength for all five types of cement, the purchaser to decide which test shall be used.

(d) *Fineness.*—The new specifications call for a fineness test using the turbidimeter. The present specifications have no fineness requirement.

(e) *Soundness.*—The new specifications call for a soundness test using an autoclave in which the specimens in the form of bars of neat cement paste, 1 in. by 1 in. by 10 in., are subjected to steam under pressure. The present specifications call for pats to be suspended over boiling water in a closed vessel.

It should be noted that additional testing equipment will be required in the testing laboratories to make the new tests which are required by the new specifications.

Your committee desires also to call attention to Section 2. Basis of Purchase, of these new specifications which reads as follows: "The purchaser should specify the type or types desired. When no type is specified, the requirements of Type I shall govern."

In the absence of adequate data on which to base a recommendation for a change in this section, the committee, for the time being, approves of the new section as it now stands. It is proposed to continue the study of the merits of the different types of cement and the uses to which they are adapted with the hope that it will be possible to report on this subject next year.

Attention is also directed to Section 6. Packaging and Marking, of these specifications, under which it is permissible to ship cement in packages without the "Type" of the cement being marked on the package. Until the extent of the demand for the various types of cement is developed and the cement manufacturers know what they will be called on to furnish, your committee feel it unwise to suggest any changes in this section, but has this matter under consideration and will continue to give it study.

In the interim, modifications of this section should be subject to agreement between the purchaser and the manufacturer.

Report on Assignment 5

Specifications for Foundations, Including Excavation, Cofferdam, Piling, Etc.

Collaborating with Committee 1—Roadway and Ballast on Soil Mechanics, and with Committee 7—Wood Bridges and Trestles on Bearing Power of Wood Piles and Pile Driving

Jamison Vawter (chairman, subcommittee), T. L. Condron, G. H. Dayett, G. F. Eberly, R. L. Mays, Roscoe Owen, O. V. Parsons, W. M. Ray, G. R. Smiley, C. H. Splitstone, C. A. Whipple, W. R. Wilson.

Bibliography on Foundations

In preparing the bibliography, presented below as information your committee has confined its search to items published in periodicals and current publications. It has not included any foreign language publications. The American Society of Civil Engineers published a very complete bibliography in August 1931, covering the entire field of foundations and soils, which is given as the first item in this bibliography. This bibliography was compiled to cover the years 1931 to 1940 and is largely confined to articles on foundations only. There are a few items in 1941 that came to the attention of the committee. It is felt that the bibliography presented here is fairly complete as an effort has been made to obtain all leading articles.

Schrero, Morris.—Bibliography of Physical Properties and Bearing Value of Soils. 1931. (Proceedings, ASCE, August, p. 871–921.) A complete bibliography with about 800 references. Subdivided under following headings:

- Bibliography
- General and Miscellaneous
- Slides, Slips, Subsidences
- Chemical and Physical Properties of Soils
- Granular Materials
- Foundations
- Retaining Walls
- Piles

Adams, H. C.—Designing Bridge Substructures. 1932. (Public Works, January, p. 49.) Design of abutment foundations—some suggestions not found in text books. An abstract from a prize winning paper in England.

Albertson, Edwin R.—Cofferdamming Difficulties in a Narrow Tideway. 1937. (Engineering News-Record, May 20, p. 729–732.) Bridging the mouth of the Shark river on the New Jersey coast called for a resourceful battle with tidal currents, ground swell and old foundation obstructions.

Allin, R. V. and Nachshen, M. — Power-House Foundations and Circulating-Water Tunnels at the Ford Motor Company Works at Dagenham. 1933. (Engineering, February 10, p. 169–170.) Foundation construction on precast piles. Site partly river foreshore and partly reclaimed land. Method used in construction described.

AREA.—Procedure to Determine the Supporting Capacity of Soils. 1932. (Proceedings, AREA, Vol. 33, p. 650–653.) Report of subcommittee on Foundations of Committee 8—Masonry.

AREA.—General Specifications for Foundations of Railway Structures. 1934. (Proceedings, AREA, Vol. 35, p. 976–979.) Report of subcommittee on Foundations of Committee 8—Masonry. (Discussion, p. 1183–1185.)

AREA.—Bearing Power and Other Physical Properties of Soils. 1934. (Proceedings, AREA, Vol. 35, p. 364–370.) Report of subcommittee of Committee 1—Roadway.

AREA.—Specifications for Foundations. 1935. (Proceedings, AREA, Vol. 36, p. 861–863.) Report of subcommittee on Foundations of Committee 8—Masonry.

AREA.—Bearing Power and Other Physical Properties of Soils. 1935. (Proceedings, AREA, Vol. 36, p. 313–316.) Report of subcommittee on above subject of Committee 1—Roadway.

AREA.—General Specifications for Sub-Structures of Railway Structures. 1936. (Proceedings, AREA, Vol. 37, p. 643–644.) Report of subcommittee on Foundations of Committee 8—Masonry.

AREA.—Physical Properties of Earth Materials. 1936. (Proceedings, AREA, Vol. 37, p. 118–123.) Progress report of subcommittee of Committee 1—Roadway.

AREA.—General Specifications for Soil Testing for Railway Foundations. 1937. (Proceedings, AREA, Vol. 38, p. 448–449.) Report of subcommittee on Foundations of Committee 8—Masonry. (Discussion, p. 722–727.)

AREA.—Physical Properties of Earth Materials. 1937. (Proceedings, AREA, Vol. 38, p. 164–167.) Progress report of subcommittee of Committee 1—Roadway.

AREA.—Specifications for Pile Foundations. 1938. (Proceedings, AREA, Vol. 39, p. 145–147.) Progress report of subcommittee on Foundations of Committee 8—Masonry. (Discussion, p. 883–884.)

AREA.—Physical Properties of Earth Materials. 1938. (Proceedings, AREA, Vol. 39, p. 316–321.) Report of subcommittee of Committee 1—Roadway.

AREA.—Specifications for Pile Foundations. 1939. (Proceedings, AREA, Vol. 40, p. 418–424.) Complete specifications presented by subcommittee on Foundations of Committee 8—Masonry. (Discussion, p. 768–769.)

AREA.—Specifications for Pile Foundations. 1940. (Proceedings, AREA, Vol. 41, p. 369–372.) Final report on above subject of subcommittee on Foundations of Committee 8—Masonry.

AREA.—Specifications for Driving Wood Piles. 1940. (Proceedings, AREA, Vol. 41, p. 326–331.) Final report on above subject of subcommittee of Committee 7—Wood Bridges and Trestles.

AREA.—Specifications for Test Borings. 1941. (Proceedings, AREA, Vol. 42, p. 321–332.) Progress report and specifications submitted by subcommittee of Committee 8—Masonry.

ASCE.—Earths and Foundations. 1933. Progress Report of Special Committee. (Proceedings, ASCE, May, p. 777–820.) Discussions: August, 1933, p. 1054–1067; September, 1933, p. 1207–1220; October, 1933, p. 1358–1372; November, 1933, p. 1461–1474; December, 1933, p. 1648–1650; January, 1934, p. 107–111. Basic principles for solving general problem of settlements of structures on soils containing strata of very fine grained saturated materials.

Andrews, Carl B.—Engineering Problems in the Tropics. 1931. (Civil Engineering. October, p. 1184–1188.) Some of the data, current in engineering practice, cannot be applied in the tropics. Soils, foundations, materials of construction and meteorology encountered differ from temperate zones.

Backherms, A. B.—Simple Soil-Bearing Test Performed at Akron Sewerage Works. 1930. (Engineering News-Record, July 24, p. 146.) Record of the settlement of different loads on a simple platform and box.

Baldock, R. H.—Bituminous Macadam Road-Building in Oregon. 1938. (Civil Engineering, May, p. 315–317.) Present methods of building bituminous macadam with careful attention given to foundations.

Bergman, Victor R.—Old Tunnel Vaults Revealed by Excavation for Building. 1938. (Engineering News-Record, September 1, p. 267–268.) Discovery of tunneled rooms with 21-ft. flat roofs under site of New York apartment changes foundation plans.

Berkenbilt, S. E.—Chicago Concrete Building Presents Difficult Foundation Problems. 1930. (Engineering News-Record, April 10, p. 619–622.) Proximity to river introduces complications.

Berridge, H.—Physical and Mechanical Properties of Clay. 1931. (Engineering, July 31, p. 126–129, August 14, p. 192–193.) Investigations and experiments on physical and mechanical properties of clay.

Besson, F. S.—Review of Soil-Bearing Test for Columbus Water Tanks. 1934. (Engineering News-Record, March 15, p. 345–346.) Failure to follow basic principles of soil mechanics vitiates test results on several important counts.

Bignell, L. G. E.—River Location Presents New Problems. 1930. (Oil and Gas Journal, December 11, p. 40.) Protection of derrick built in middle of North Canadian river in Oklahoma City field, accomplished by "Battleship" barrier.

Borhek, Russell.—Bridge Foundation Failures. 1940. (Roads and Streets, May, p. 76.) Discussion of results of questionnaire of committee of American Railway Bridge and Building Association.

Bowen, S. W.—Use of Caissons in St. Louis Sub-Soil. 1931. (Civil Engineering, January, p. 309–311.) Limestone caves in bedrock present difficult problems in foundation work. Eccentric results obtained in test borings. Open-well type of reinforced concrete caissons used.

Brodhead, R. J.—Blasting Limestone Inside a Building. 1934. (Explosives Engineer, September, p. 263.) Excavating six feet of solid limestone inside a newly constructed gymnasium at Barneveld, Wis., required accurate control of blasting.

Brown, Victor J.—World's Deepest Bottom-Door Type Open-Well Caissons. 1939. (Roads and Streets, May, p. 33–41.) Illustrations and description of caissons being sunk in surging tidestream of Tacoma Narrows. Swift deep rough water major problem of contractors and engineers.

Burd, Edward M.—High Dams on Pervious Glacial Drift. 1934. (Transactions, ASCE, Vol. 99, p. 792–818.) Discussion, p. 819–846. Generalities of design and construction for such foundations based, to large extent, on Hardy Dam, on the Muskegon river, in Michigan.

Burmister, Donald M.—Grading-Density Relations of Granular Materials. 1938. (Proceedings, ASTM, Vol. 38, Part II, p. 587–596.) Discussion, p. 597–601. Importance of these relations since density is an important factor in the supporting capacity of the natural soil.

Burmister, Donald M.—Graphical Distribution of Vertical Pressures Beneath Foundations. 1938. (Transactions, ASCE, Vol. 103, p. 303–313.) Discussion, p. 314–343. At present Boussinesq equation for the pressure at a point within the soil mass, due to a point load concentrated at the surface, the logical basis. Method of influence line and graphical integration suggested.

Burmister, Donald M.—A Low Cost Soil Testing Outfit. 1939. (Engineering News-Record, August 31, p. 276–278.) Descriptions and working drawings of soil testing apparatus that can be made in any college or highway department shop at costs within the means of the most scanty budget.

Butler, F. B.—Portland Cement Stabilization Applied to Foundation Construction. 1939. (Civil Engineering, July, p. 412–413.) Due to existing foundations which could not be disturbed, the problem arose of method of constructing a foundation to carry a dead load of over 14,000 tons. Solved by stabilization of soil.

Casagrande, Arthur.—Compressibility of Clay Increased by Remolding. 1932. (Engineering News-Record, August 11, p. 159–161.) Description of tests which show an increase of compressibility of remolded clay compared with the same clay in the undisturbed state.

Casagrande, Arthur.—Soil Mechanics Progress. 1937. (Engineering News-Record, February 4, p. 179–180.) The First International Conference on Soil Mechanics and Foundation Engineering. Review of progress in 1936.

Case, Montgomery B.—George Washington Bridge: Construction of Substructure. 1933. (Transactions, ASCE, Vol. 97, p. 206–241.) Discussion, p. 434–435. The principle features of the construction methods used on the foundations for the main piers and the anchorages for the cables are described in this paper.

Chambers, Robert H.—Tolerances and Reinforcing for Tilted Cylindrical Piers. 1937. (Engineering News-Record, October 7, p. 606–607.) Three cases in New York City vary widely in treatment of out of plumb deep caissons.

Chatley, Herbert.—The Principles of Foundation Design. 1939. (Engineering, Dec. 15, p. 670.) New methods used in foundation design against old empirical principle.

Christenson, E. J.—Dam Foundation Compacted by Pile Driving. 1939. (Civil Engineering, February, p. 92–93.) Consolidation of dredge-placed sand fill near Red Wing, Minn.

Colburn, R. T.—Sheet-Pile Cofferdams and Test Cell for TVA Projects. 1939. (Civil Engineering, September, p. 551–553.) Construction and demolition of circular-cell sheet-pile cofferdams. Use of freezing to aid in the excavation of a deep, sheet-pile-lined test cell.

Comber, T. F. and Coan, J. M.—Model Tests, Bridge Pier Supported on Long Steel Piles. 1941. (Transactions, ASCE, Vol. 106, p. 970–989.) Discussion, p. 990–991. Gives the results of tests on a model of a proposed deep-water bridge pier supported on long, tubular steel piles. Pier stresses and pier deflections were measured in the model from which corresponding values may be determined in the prototype.

Condron, T. L. and Math, E. R.—Investigating a Foundation in Soft Soil. 1932. (Civil Engineering, April, p. 237–241.) Use of borings, test piles and soil bearing tests to determine type of foundation suitable for building on soft surface soil. Comparative estimates are given of the cost of foundations supported on wood and concrete piles.

Cummings, A. E.—Distribution of Stresses Under a Foundation. 1936. (Transactions, ASCE, Vol. 101, p. 1072–1083.) Discussion, p. 1084–1134. Compares theory and experiment and indicates several important factors which must be considered when problems of this kind are being analyzed.

Cummings, A. E.—Foundation Stresses in an Elastic Solid with a Rigid Underlying Boundary. 1941. (Civil Engineering, November, p. 665–667.) Stress distribution in a bed of soil of finite depth overlying rock. Boussinesq equations cannot be used for such a problem. Equations given for uniformly distributed surface load.

Davey, T. F.—Marine Oil Well Construction. 1931. (Civil Engineering, May, p. 721–726.) Special foundations and platforms required for drilling in submarine oil fields. Description of a number of types of construction at depths of water up to 100 ft.

Dawson, Raymond F.—Settlement Studies on San Jacinto Monument, Texas. 1938. (Civil Engineering, September, p. 589–591.) Field observations supply data on behavior of isolated footing on deep bed of clay. Technique of making observations, and results up to date. Observations carried on for two years; compared with previously predicted laboratory tests.

Deignan, J. E.—Measuring Bed Rock Action Under Tygart Dam. 1936. (Engineering News-Record, May 21, p. 731.) Elastic wire strain meters registering at nine depths from 30 to 170 ft. will be read for deformations of foundation rock.

Deutschman, Nathan.—New York's Latest Interborough Bridge. 1939. (Engineering News-Record, Nov. 23, p. 706–709.) Acid soil required special foundation design and alkalizing procedure.

Dewell, Henry D.—Experience in Driving and Testing Composite Piles. 1938. (Civil Engineering, September, p. 574–577.) Special care given to construction methods and specifications. Test data on strength of splices in composite piles.

Dow, Arthur L.—Foundation Exploration in Deep Water. 1937. (Engineering News-Record, October 14, p. 635–640.) Soil sampling and core drilling successfully carried on in deep and swift moving tidal waters of Passamaquoddy Bay with floating equipment.

Eckles, Harry E.—Design of Pile Foundations Using Piles of Varied Lengths. 1940. (Engineering News-Record, June 20, p. 862–863.) More economical design and use of pile foundations.

Eckles, Harry E.—Design of Retaining Wall Footings. 1938. (Civil Engineering, November, p. 749–750.) Careful investigation necessary to avoid excessive bond stresses.

Ehrenburg, D. O.—Measuring Soil Moisture. 1937. (Engineering News-Record, May 13, p. 708–710.) Tests by Bureau of Reclamation bring out new facts on effects of compaction, temperature, grading and composition of the soil.

Ellsberg, E. and Kandel, C.—New Steel Sheetpile Cutting Record Set for Underwater Work. 1937. (Engineering News–Record, March 11, p. 373–375.) Underwater cutting of steel sheet-piling in the caissons for the Marine Parkway bridge at New York establishes a new record for speed and economy. Diver working in 30 ft. of water cut 2,000 piles.

Engineering News–Record.—New Data on Structures and Foundations. 1940. (Engineering News–Record, February 1, p. 174–176.) From papers presented at ASCE meeting in New York in January 1940. Covers: Building Foundation Design; World's Fair Foundations; Wind Design Procedure; Settlement from Excavation; Concrete Slab Design.

Ensz, Herbert.—Model Studies in Foundation Engineering. 1938. (Journal of W. Soc. of Eng., October, p. 258–263.) A practical study of soils for foundations using models. Model studies for rigid-frame foundations; for earth pressure against retaining walls; for investigating stability of embankment foundations; of seepage flow in earth dams.

Evans, L. T.—Smokestack Foundation Designed Against Earthquake. 1934. (Engineering News–Record, September 13, p. 344–345.) Novel feature of foundation resists earthquakes. Formula for calculation and method of design described.

Feld, Jacob.—A Foundation Primer. 1938. (Civil Engineering, January, p. 10–14.) Demonstrating facts and fallacies, especially as applied to small buildings. Limitation and peculiarities of some materials encountered, suggestions for avoiding pitfalls and taking advantage of favorable qualities of the materials.

Fidler, Harold A.—Proving Rings Register Soil Shear. 1939. (Engineering News–Record, June 8, p. 764.) Steel proving rings adopted for measuring shear resistance in an improved shear-testing machine at M. I. T. soils laboratory.

Forbes, Hyde—Cyclic Load Tests Develop Data in Recent Foundation Investigations. 1936. (Western Construction News, April, p. 110–112.) Supporting value and yield point of soils determined by loads repeatedly applied and released. Behavior and bearing values of similar soils vary with factors of deposition method, moisture content and drainage conditions.

Foster, H. A. and Glick, G. W.—Foundations on Deep Fill. 1938. (Engineering News–Record, September 22, p. 361–366.) Spread footings or long piles were used, depending upon the character of the underlying fill as revealed by soil and bearing tests for New York World's Fair.

Freeman, George L.—Deep Caisson Work at the Whitestone Bridge. 1939. (Engineering News–Record, August 3, p. 149–153.) Foundations for New York Suspension bridge include square, rectangular and circular concrete caissons and square hollow-wall welded steel box caissons, the latter designed to float until cutting edge was at a 100-ft. depth.

Freeman, George L.—A Practicing Engineer Looks at Soil Mechanics. 1938. (Civil Engineering, December, p. 811–814.) Its applications and its limitations. Suggests a brief basic bibliography on the subject.

Freyssinet, M. E.—Developments in Concrete Making. 1936. (Concrete and Constructional Engineering, April, p. 209–219.) New process tests 5,000 pounds per square inch in 2 hours after mixing. Finds use in foundations and piles. Abstract of paper read before Institution of Structural Engineers.

Geen, Burnard.—Modern Treatment of Foundations on Difficult Sites. 1937. (Surveyor, April 9, p. 523–524.) His objections to deep piers; heavy raft foundations; uniformity of settlement; study of the subsoil for determining safe pressures; soil changes during excavations especially effect of water.

Gilboy, Glennon.—Developments in Soil Knowledge. 1938. (Engineering News–Record, February 10, p. 241–243.) Knowledge of settlement, earth dam design, compaction of embankments and yielding of dam foundations was advanced during the year.

Gilboy, Glennon.—Improved Soil Testing Methods. 1936. (Engineering News–Record, May 21, p. 732–734.) New instruments for consolidation, shear and permeability tests contributed to the soil investigations on the Muskingum project.

Gilboy, Glennon.—The Scientific Method in Earthwork. 1937. (Civil Engineering, December, p. 827–830.) Rule-of-thumb procedure yields to application of principles of soil mechanics in foundation problems. Contributions of soil mechanics to design of spread and pile foundations, retaining walls and earth dams.

Gillette, Major D. H.—Washington Monument Facts Brought up to Date. 1933. (Engineering News–Record, April 20, p. 501–502.) Borings carried to rock for first time reveal a layer of soft clay potentially unstable under any large and unbalanced loading such as would result from the proposed landscaping operations.

Gilman, George T.—Railroad Viaduct Carried Through Occupied Building. 1933. (Engineering News–Record, November 30, p. 641–644.) Foundations adjacent to building footings on piles consist of steel cylinders jacked to rock under air and filled with concrete. Viaduct carefully insulated from building occupied by Bell Telephone Laboratories in New York.

Glick, G. W.—Rigid Rectangular Frame Foundation for Albany Telephone Building. 1930. (Engineering News–Record, Nov. 27, p. 836–838.) Two-story reinforced concrete frame work without diagonal members insures equal settlement on yielding soil with column loads unequal.

Glick, George W.—Skyscraper Foundations in Quicksand Area Built Within Open Cofferdam. 1931. (Engineering News–Record, March 26, p. 515–519.) Usual pneumatic caissons replaced by full-lot cofferdam for 60-story building. City Bank Farmers Trust Building in Lower Manhattan.

Goodenough, B. W. and Rhoades, R. T.—Freezing Aids Shaft Excavating. 1939. (Compressed Air Magazine, January, p. 5778–5782.) Operations at Gilbertsville dam demonstrated that earth refrigeration as an aid to excavation has many advantages.

Gordon, Grant.—Arch Dam of Ice Stops Slide. 1937. (Engineering News–Record, February 11, p. 211–215.) Basic assumptions for computing dam resistance and details of freezing procedure having record value for future operations.

Gray, W. S.—Shallow Foundations. 1936. (Concrete and Constructional Engineering, May, p. 280–298.) Determining distributions of vertical reactions. Use of theory of loads supported continuously on elastic material and the modulus of soil reaction.

Greve, Frederic.—Soundings for Bridge Foundations. 1933. (Public Works, February, p. 24.) Necessity of soundings to prevent loss of time, higher costs and change of plans. Method and procedure of soundings used described. Abstract of paper by writer.

Griffith, C. L. T.—Foundations for Stanchions Subject to Overturning Moment. 1935. (Concrete and Constructional Engineering, June, p. 337–343.) Three qualities to consider, dead load, maximum safe bearing pressure of ground and overturning moment. Covers different cases.

Griffith, James R.—Short Cuts in Structural Design—Intensity of Pressure Under Footings. 1931. (Concrete, April, p. 36–38.) Time saving chart aids in computing soil pressures under foundation walls.

Griffith, James R.—Short Cuts in Structural Design—Earth Pressure Against Foundation Walls. 1931. (Concrete, October, p. 29–30.) New chart provides ready means of determining pressure against foundation walls when height and character of earth fill are known.

Grillage.—British Methods of Sinking Test Borings and Trial Pits. 1931. (Engineering and Contracting, October, p. 269–274.) British methods of obtaining information about strength, soundness and character of foundations, as well as their drilling methods for oil or water. Complete description of equipment used.

Grover, La Motte.—Removing Submerged Steel by Blasting. 1937. (Engineering News–Record, November 4, p. 758.) Exploding charges sunk in metal tubes break up truss members of flood-wrecked bridge. Discussion and diagram on method used.

Grover, La Motte.—Well Points on Small Bridge Work. 1937. (Engineering News–Record, June 10, p. 877–879.) The use of well points in place of more conventional foundation methods on several Kansas jobs results in satisfaction, speed and economy.

Hammond, Henry D.—Model of Test Borings. 1938. (Engineering News–Record, October 13, p. 476.) Model made of the test borings for the General Motors Building at the New York World's Fair. Shows contours of the division of the soil materials. Great aid in determining the proper penetration of piles into bearing soils.

Hays, James B.—Improving Foundation Rock for Dams. 1939. (Civil Engineering, May, p. 309–312.) Grouting technique described and illustrated.

Helmers, N. F.—Pier Foundations for the New Orleans Bridge. 1936. (Civil Engineering, July, p. 442–445.) Difficult work successfully concluded by use of sand islands for caissons. Open-dredged caissons used.

Herbert, W. F. and Anderson, H. E.—Foundations Used in Marsh Operations. 1937. (Oil and Gas Journal, April 8, p. 57–64.) Discussions on the three types, earthen fill, wooden mats and superstructures, and piling foundations. Discusses driving formulas of the bureau of yards and docks of the Navy Department.

Herwitz, O. C.—The Risk of the Unexpected in Sub-Surface Construction Contracts. 1940. (Transactions, ASCE, Vol. 105, p. 454–475.) Discussion, p. 476–503. Aid to help draw up contracts that will not return to plague both owner and contractor. Discusses reports of borings and similar data. Cites a number of court decisions.

Hogan, J. P.—Up from the Ashes. 1939. (Scientific American, February, p. 76–78.) New York World's Fair, 1939; engineering difficulties of filling in and building upon ash-filled swamp muck.

Housel, W. S.—Bearing Power of Clay is Determinable. 1933. (Engineering News–Record, February 23, p. 244–247.) Clay has a definite bearing capacity, and soil tests can be interpreted so as to make possible the design of substructures for known and limited amounts of settlement.

Housel, W. S.—A Practical Method for the Selection of Foundations Based on Fundamental Research in Soil Mechanics. 1929. (Department of Engineering Research, University of Michigan, Ann Arbor. Engineering Research Bulletin No. 13.) Methods used and conditions encountered, straight line equation for bearing capacity, general equation to express fundamental relations, appendix on development of the physical characteristics ratio.

Howard, E. E.—New Pier Design for Deep Overburden. 1939. (Engineering News–Record, November 23, p. 687–688.) Piers for the new Missouri River bridge at Brownville, Neb., consists of sheetpiles riveted to I-beams and driven in a circle to bedrock, with the enclosed sand plugged at the top with concrete. Cost is 18 percent less than pneumatic caissons.

Irwin, Daniel.—Small Refinery Tanks May be Mounted at Low Costs by Following Simple Rules. 1934. (Oil and Gas Journal, May 10, p. 42.) Types of foundations that can be used to save space, accessibility, ease of inspection, maintenance and drainage.

James, J. R.—Lateral Clay-Pressure Phenomena in a Detroit Foundation. 1932. (Engineering News–Record, March 31, p. 479–480.) Goldbeck cells in caisson walls disclose eccentric and also unexpected great lateral pressures in constructing power-house foundations in Detroit clay.

Jarvis, Clarence S.—Foundation of the Washington Monument. 1932. (Civil Engineering, June, p. 411–412.) Discussion on underpinning of Washington Monument. Early controversies over adequacy of foundation.

Johnson, W. O.—Excavating Close to Building Without Underpinning. 1933. (Engineering News–Record, September 28, p. 376–377.) Deep sewage regulator alongside shallow foundation constructed in sections to avoid underpinning. Regulator wall buttressed to serve as maintaining wall.

Keast, Sheldon A.—Design of Subway Foundations in Philadelphia. 1933. (Civil Engineering, December, p. 681–683.) Method used to provide against uplift and entrance of ground water.

Koefoed, S. M.—Four Cofferdams for Forty-One Foundations. 1939. (Engineering News–Record, July 6, p. 15–17.) Repetitive use of floating cofferdams for Storstrom bridge in Denmark; structure of coffers and methods of using them described; 20-foot high sections of stone-faced concrete pier shafts built on shore and floated to place on pier bases.

Krynine, D. P.—Pressures Beneath a Spread Foundation. 1938. (Transactions, ASCE, Vol. 103, p. 827–849.) Discussion, p. 850–888. "Reduced area method" of determining pressures under both uniformly and non-uniformly loaded foundations. Rigidity of structures and earth masses principally from the standpoint of their interaction.

Krynine, D. P.—Soil Action Under Load Shown by Test. 1932. (Engineering News–Record, December 29, p. 782–784.) Movement of soil under test load disclosed by excavating vertical cut under loaded area and by observing soil movement and moisture condition, with analysis of determinations.

Lane, E. W.—Security from Under-Seepage—Masonry Dams on Earth Foundations. 1935. (Transactions, ASCE, Vol. 100, p. 1235–1272.) Discussion, p. 1273–1351. Results of study of more than 200 dams. Determination of the length of percolation path to prevent failure from under-seepage or piping. Method of analysis to permit smaller seepage distances than ordinarily considered safe.

Lasker, Julius.—Ingenious Cantilever Foundation. 1939. (Engineering News–Record, September 14, p. 350–351.) Cantilever foundation designed to straddle existing chimney footing and relieve it of any building load.

Lee, Chesman A.—Foundations and Supports. 1939. (Chemical and Metallurgical Engineering, May, p. 330–332.) A discussion of foundations for equipment.

Linthacum, W. W.—Three Duty Test Drill Rig. 1938. (Engineering News–Record, December 1, p. 712–713.) Test drill rig combines a test drill with rotary spudder and wash-bore attachments.

Lundy, Wilson T.—Grande Ecaille Sulphur Development Overcomes Marsh Conditions. 1934. (Chemical and Metallurgical Engineering March, p. 116–120.) Foundation construction, involving great difficulty, was accomplished by supporting a reinforced concrete mat on 75 ft. piles.

Lyman, A. K. B.—Compaction of Soils by Explosives, 1940. (Civil Engineering, April, p. 205–207.) Economical and efficient use of explosives for first time in earth compaction. Used successfully to consolidate loose sand deposits at Franklin Falls dam site.

Lynn, A. V. and Rhoades, R. F.—Foundation Exploration at Kentucky Dam. 1940. (Engineering News–Record, October 10, p. 480–483.) For more than four years prior to start of construction the TVA conducted an intensive exploration of the site. Article shows completeness of integration of engineering and geological observations.

Marsh, C. P.—Deep Foundations at Cleveland Union Station. 1930. (Engineering News–Record, September 4, p. 363.) Notes from paper delivered by C. P. Marsh before meeting of the ASCE. Tower supported on concrete piers in wells sunk 200 ft. in rock. Bearing tests and settlement. Cost of foundation was $1.25 per cubic ft.

Marsh, C. P.—Foundations for the Cleveland Union Terminal. 1930. (Civil Engineering, November, p. 83–88) Great cost of extending footings 204 ft. below rail level warranted extreme care both in making physical-bearing tests and scrutinizing every possibility of founding the building at some shallower depth. How problems have been solved.

Masters, Frank M.—Timber Friction Pile Foundations. 1941. (Proceedings, ASCE, November, p. 1657–1682.) Theory presented developed in connection with pile tests on the Morganza Floodway in Louisiana. May determine safe loads on groups of piles from data secured by loading to failure one or more individual friction piles at the site.

McHugh, F. D.—Foundation Exploration with 36 in. Drills. 1937. (Scientific American, December, p. 350.) Large drill holes permit engineer to enter and examine the walls. Methods of drilling described.

McIntosh, W. T.—Unusual Foundation for 71-Story Building. 1930. (Engineering News–Record, April 24, p. 691–695.) Foundations for building built underneath old buildings while the process of wrecking was being carried on. Steel erection began as soon as site was cleared. Exceptionally large cylinders sunk by jacking.

McIntosh, W. T.—Foundations for Bank of Manhattan Tower. 1930. (Engineering and Contracting, February, p. 67–73.) Contractors install foundations for 103 columns for 71-story building while old buildings were being wrecked. Ready for steel erection two days after demolition.

McIntosh, W. T.—Extra Long Cylinder Piles Carry Column Loads to Rock. 1932. (Engineering News–Record, July 7, p. 5–7.) Steel cylinders driven from 60 to 140 ft. to rock and blown out by compressed air form foundations of Starrett–Lehigh building in New York. Tests show settlement ⅛ in. under 1½ times the designed load.

Melick, Neal A.—Difficult Steel-Cylinder-Pile Foundation Construction. 1931. (Engineering News–Record, August 13, p. 267–269.) Stone-filled log cribs and uneven foundation. Rock surface wrecks thin shell piles. Three quarter inch and thicker shells recommended for hard driving.

Mercer, L. B.—Some Basic Principles of Grain Elevator Design. 1934. (Engineering News–Record, July 19, p. 77–81.) Foundations, bin arrangements, working-house size and shape must be selected on basis of economy both of construction and operation. Different requirements for terminal layouts and country elevators.

Meyer, M. B.—Foundation Design for an Elevated Tank. 1932. (Engineering News–Record, December 1, p. 644–645.) Girder continuity and large number of heavily loaded columns in new 1½ m. g. radial cone bottom tank at Evanston, Ill. make foundation design controlling. Tank bottom and girders are welded.

Miller, Robert M.—Foundation Methods Involving Piling. 1932. (Civil Engineering, May, p. 304–308.) Making foundation piling contracts flexible enough to permit selection of types of pile best adapted to conditions found. Advantages and characteristics of various types of piles.

Miller, R. M.—Soil Reactions in Relation to Foundations on Piles. 1938. (Transactions, ASCE, Vol. 103, p. 1193–1216.) Discussion, p. 1217–1236. Based on records from 250 pile-driving projects. Data on pile foundations under varying soil conditions. Twenty-three examples.

Morgensen, O. E.—A Caisson Foundation Job. 1931. (Civil Engineering, January, p. 311–314.) Type of caisson best adapted for new plant of Missouri Portland Cement Company at Prospect Hill, Mo. Type used extensively in vicinity of St. Louis.

Moran, D. E.—Sampling and Soil Tests for Bay Bridge, San Francisco. 1933. (Engineering News–Record, October 5, p. 404–406.) Method of taking soil samples at the great depths to which the foundations of the San Francisco–Oakland bridge penetrate. Methods and results of sample tests. Consolidation tests and testing apparatus.

Moran, D. E. and Dufour, F. O.—Increasing the Bearing Power of Clay Soils. 1932. (Engineering News–Record, May 19, p. 726.) High pressure subsoil injection into clay under concrete floor increases bearing power. Pressure grouting raises cement slab to former position.

Morgan, R. T.—Foundation Work at the New Nurses' Home and Medical School, Westminster Hospital. 1936. (Concrete and Constructional Engineering, October, p. 525–536.) Construction of concrete foundation for building 280 ft. long and 98 ft. wide on marshy site underlain with London blue clay. Detailed design of retaining walls.

Morrison, I. F.—The Fundamentals of Pile Foundations. 1939. (Canadian Engineer, December 19, p. 4–7.) A discussion of several types of pile foundations designed to show principles regarding reciprocal action between the ground, the piles and the structure supported by them.

Mullis, Ira B.—Principles Applying to Highway Road-Beds. 1939. (Transactions, ASCE, Vol. 104, p. 1381–1401.) Discussion, p. 1402–1424. Mechanical properties of typical earthy foundations set forth with reference to their suitability for roadbed use. Construction methods and experience are presented and discussed.

Napier, E. J.—Canadian National Railway uses 175 ft. Steel Piles to Bridge Kinojevis River. 1939. (Canadian Engineer, May 16, p. 4–7.) Illustrations and diagrams showing how Canadian National Railway engineers used 175 ft. steel piles in a bridge.

Newmark, N. M.—Estimating Earth Pressures. 1938. (Engineering News–Record, January 6, p. 23–24.) Simple chart speeds up the computation of vertical earth pressures caused by foundation loadings.

Newmark, N. M.—Simplified Computation of Vertical Pressures in Elastic Foundations. 1935. (Engineering Experiment Station, University of Illinois, Circular No. 24.) Vertical stress due to load uniformity distributed over a rectangle. Limiting cases. Numerical examples.

Paaswell, George.—Penetration Tests Give Bearing Power of Deep Subsurface Soils. 1931. (Engineering News–Record, April 2, p. 570–572.) Steel points pushed down from surface pre-determine load capacity and probable settlement of soil under section of New York subway having a building load surcharge.

Pagon, W. W.—Transatlantic Seaplane Base, Baltimore, Md. 1941. (Transactions, ASCE, Vol. 106, p. 1340–1360.) Discussion, p. 1361–1362. The difficult foundation conditions and the unusual hangar design dictated by these conditions, caused by the character of the mud fill.

Palmer, L. A.—Design of a Fill Supported by Clay Underlaid by Rock. 1939. (Public Roads, October, p. 157–162.) An application of soil mechanics in solving a highway fill problem.

Pape, Paul F.—Earthquake Design for Bank Buildings. 1933. (Engineering News–Record, April 13, p. 457–460.) Four new branches of the Mitsui Bank in Japan illustrate the application of modern earthquake-proof design practices. Foundations and superstructure.

Peck, Ralph B.—Soil Tests Check Chicago Subway Work. 1939. (Engineering News–Record, December 7, p. 769–770.) Soil variation on Chicago subway tunnels prompted elaborate subsoil exploration programs. Bore-hole samples taken every 300 ft. for laboratory tests.

Peckworth, Howard F.—Field Control of Compacted Earth Fill. 1939. (Civil Engineering, April, p. 221–223.) A fill of compacted earth controlled from the field—with illustrations.

Pokrowski, G. I. and Laletin, N. W.—Model Tests of Soil Action Under Footings. 1932. (Engineering News–Record, September 15, p. 309–311.) Results of tests at civil engineering high school at Moscow are shown by photographs taken through glass containers of soil movement under piles and various forms of footings.

Porter, J. P.—The Supporting Value of Piled and Other Deep Foundations. 1936. (Concrete and Constructional Engineering, June, p. 319–331.) Site and types of foundations; static formula for pile groups and deep foundations; factor of safety; where use of cylinders is preferable to piles.

Prior, John C.—Soil-bearing Tests for Columbus Water Tanks. 1933. (Engineering News–Record, October 26, p. 500–502.) Settlements of test columns and foundations harmonize closely. Soil yieldpoint plainly shown.

Proctor, Carlton S.—Deep Foundations for High Buildings. 1932. (Civil Engineering, March, p. 137–141.) Study of foundation designs on safety and economy of construction. Trend toward open-pit excavation for supports of tall and heavy buildings.

Proctor, Carlton S.—Code of Standard Practice for Bridge Substructures. 1933. (Civil Engineering, March, p. 129–133.) Allocation of responsibility that should be assumed between owner and engineer and between these two and contractor on a bridge foundation.

Proctor, R. R.—Field and Laboratory Verification of Soil Suitability. 1933. (Engineering News–Record, September 21, p. 348–352. Consolidation and percolation tests and test results. Saturated plasticity. Swelling and bearing power.

Rhodes, E. O.—A Machine for Testing Highway Subgrade Soils. 1938. (Proceedings, ASTM, Vol. 38, Part II, p. 551–572.) Discussion p. 573–574. Use of a mechanical device, called the Plastograph, for testing the suitability of a soil for a highway foundation.

Richardson, H. W.—Reconstruction of Fort Peck Dam. 1939. (Engineering News–Record, May 11, p. 650–652.) Repairs to slumped section of Fort Peck dam have started with placing of a dry-rolled core and a new sheetpile cutoff wall. Pumping hydraulic fill to replace slide loss.

Rush, D. B.—The Bearing Power of Soils. 1930. (Proceedings, AREA, Vol. 31, p. 1176–1190.) A monograph by D. B. Rush as a part of the report of Committee 8—Masonry.

Russell, I. E.—Design of Highway Foundations. 1939. (Concrete, July, p. 6.) Accepted designs of highway foundations.

Sack, N. R.—Probing for Bridge Foundations. 1939. (Engineering News–Record, October 12, p. 481–484.) Practical methods and tools developed by the Missouri highway department for subsurface exploration for bridge foundations; tools and operating procedure are described in detail for the direction of the field worker.

Sandstrom, C. O.—Designing Foundations for Self-Supporting Towers. 1932. (Chemical and Metallurgical Engineering, May, p. 270–272.) Different types of foundations that can be used. Determination of suitable type.

Shepard, E. R.—Searching for Foundation Beds by Electricity and Sound. 1935. (Engineering News–Record, August 15, p. 228–232.) Experimentation by the Bureau of Public Roads demonstrates wide usefulness of both earth-resistivity and seismic subsurface surveys with easily portable field apparatus.

Siebert, E. C. and Palmer, L. A.—A Soil Survey by Stabilometer. 1938. (Engineering News–Record, June 9, p. 813–814.) Soil characteristics measured in terms of pressure on dry dock and cofferdam walls by stabilometer and direct-shear test apparatus.

Simpson, Willard E.—Foundation Experiences with Clay in Texas. 1934. (Civil Engineering, November, p. 581–584.) Special treatments found efficacious to provide for settling and swelling action in plastic soils. With proper construction on clay soil in its natural state, settlement may reduced to a safe amount and destructive heaving largely prevented.

Skempton, A. W.—Settlement Analysis of Engineering Structures. 1938. (Engineering, September 30, p. 403–406.) Possible to estimate the settlements which any proposed structure will undergo and therefore design a foundation with a measure of certainty.

Skerrett, R. G.—New York Newspaper Building New Home. 1931. (Compressed Air Magazine, April, p. 3440–3445.) Ten-story structure erected on ground where Hudson river once flowed.

Smith, H. G.—Some Notes on the Design of Concrete Foundations. 1933. (Canadian Mining Journal, April, p. 154–155.) Methods of design whereby foundations will be safe but economical as regards dimensions. For bases of motors, machinery, etc.

Spelman, E. C.—Foundations for Central National Tower, Battle Creek, Mich. 1931. (Engineering and Contracting, January, p. 1–4.) Piles put down by aid of water jet on site where water was an ever-present hazard.

Spillman, Harry.—Cylinder Underpinning Checks Sinking Foundation. 1932. (Engineering News–Record, April 14, p. 544–545.) Supports at critical points expected to check rate of settlement until consolidation of ground brings building to rest.

Stephenson, H. K. and Feingold, E. B.—Foundation Soil Overloading Shown by Penetration Test. 1932. (Engineering News–Record, August 11, p. 161–162.) Cracks due to overloading of foundation leads to suit by St. Anthony's Church. Trunkline sewer in front of church negligible force.

Steuermann, S.—A New Soil Compacting Device. 1939. (Engineering News–Record, July 20, p. 87–88.) A combination of water jetting and vibration developed in Germany for soil compaction. Two foundation operations described. Application to embankment solidification indicated.

Stipe, C. G. and Kelly, S. F.—Geophysical Methods Aid Construction Work. 1937. (Civil Engineering, April, p. 264–268.) Recent advances showing economy and utility in exploring subsurface conditions; seismic and electrical methods; location of rock surfaces for dam, tunnel, harbor and highway construction; determination of water bearing strata; prediction of soundness of rock formations; location of sand and gravel deposits.

Summers, H. J.—Determining Bearing Power in Earth Foundations. 1934. (Engineering News–Record, April 19, p. 499–501.) Tests, theory and interpretations of bearing tests conducted for foundations of an elevated water tank.

Tennessee Valley Authority, Foundation Experiences.—A Symposium. 1941. Foundation Treatment and Reservoir Rim Tightening at Norris Dam, James S. Lewis, Jr.—Foundation Exploration and Geologic Studies at Guntersville Dam, Robert M. Ross.—Foundation Conditions and Treatment at Guntersville Dam, Verne Gongwer.—Foundation Exploration and Geologic Studies at Chickamauga Dam, Portland P. Fox.—Foundation Treatment at Chickamauga Dam, James B. Hays. (Transactions, ASCE, Vol. 106, p. 685–801.) Discussion, p. 802–848.

Terzaghi, Karl.—Settlement of Structures in Europe and Methods of Observation. 1938. (Transactions, ASCE, Vol. 103, p. 1432–1448.) Part of a symposium on practical application of soil mechanics. Discussion of symposium, p. 1449–1502. Study of the settlement of structures made from observation of buildings on pile foundations. Comparison between settlement of individual piles under load tests with that of entire foundation. Description of instruments and benchmarks used for observations.

Terzaghi, Karl.—Soil-Loading Test Practice in Europe. 1932. (Engineering News–Record, August 11, p. 158–159.) Describes and appraises the unusually ingenious apparatus and methods devised by European engineers for determining the ability of soils to carry foundation loads.

Tschebotareff, G. P.—Simple Soil-Test Machine. 1938. (Engineering News–Record, November 10, p. 581–582.) Shear test machine convertible for compression tests developed at Princeton University Soils Laboratory.

Tschebotareff, G. P.—Settlement Studies of Structures. 1938. (Civil Engineering, November, p. 751–753.) Full scale "control observation" the only reliable source of data on many important soil characteristics. Examples of failure of pile driving formulas and methods of soil investigation previously in use.

Tschebotareff, G. P.—Settlement Studies of Structures in Egypt. 1940. (Transactions, ASCE, Vol. 105, p. 919–945.) Discussion, p. 946–972. Settlement studies of foundations constructed within a radius of several hundred miles. Principles of modern soil mechanics applied. Suggests that settlement studies be taken in all large cities.

Turner, C. A. P.—Wood Borers Remove Piles from Building Foundations. 1933. (Engineering News–Record, August 10, p. 159–160.) Loft building in St. Paul, Minn., settles dangerously because wood borers eat wood piles out from under walls and column footings. Working of the borers described.

Turner, Leslie.—Some Bridge and Foundation Problems. 1936. (Surveyor, March 13, p. 411–412.) Scheme carried out by author in building bridges and foundations on site of reclaimed marshlands in Macedonia.

Van de Greyn, E. B.—Test Pit Timbering and Tools. 1939. (Engineering News-Record, January 19, p. 111. (New Mexico state highway department engineers use test pits to predetermine ground conditions. List of methods and equipment that is used in test pit construction.

Vetter, C. P.—Design of Pile Foundations. 1939. (Transactions, ASCE, Vol. 104, p. 758–778.) Discussion, p. 779–811. Presents rational methods for the determination of stresses in the individual piles of a pile foundation which supports a rigid structure such as a bridge pier or a hydraulic gate pier.

Vierheller, Howard A.—Lateral Loading Tests Made on Steel Bearing Piles. 1937. (Engineering News-Record, May 6, p. 667–669.) Tests made on large H-section piles driven 28.5 ft. into sand and gravel under Emsworth dam on the Ohio river to determine what lateral loads could be assumed, in the design of the structure. Results of tests.

Viterbo, L. R.—Contractual Procedure for Foundations of Buildings. 1933. (Civil Engineering, March, p. 126–129.) Recommends certain contractual relationships and responsibility between owner, engineer and contractor in the construction of foundations for buildings.

Vivian, C. H.—Reconstructing the Austin Dam. 1939. (Compressed Air Magazine, June, p. 5895–5902.) Illustrations and diagrams showing reconstruction of the Austin dam.

Von Voigtlander, O.—Power Plant Foundations. 1932. (Power, June 14, p. 881–884.) Problems and solutions to be met with in providing adequate substructure.

Vose, Richard H.—Concrete Foundations Treated as Engineering Problem. 1932. (Concrete, February, p. 25–26.) Types of foundations and their relation to soil discussed.

Vose, Richard H.—Spread Footings, Mat Foundations and Deep Foundations. 1932. (Concrete, March, p. 21–23.) Second paper of series. Deals with spread footings, mat foundations, and foundations carried to greater than ordinary depth, such as piles and caisson piers.

Werner, S. D.—Novel Support Holds Columns During Foundation Alterations. 1930. (Engineering News-Record, May 8, p. 776–777.) A support, essentially a guy derrick, using existing column as mast and 10-in. H-beam for holding two columns of an interior bent.

Wharton, Mel.—The Municipal Pier and Bulkhead System of Long Beach, Cal. 1930. (Engineering and Contracting, April, p. 169–171.) Work includes one of the largest piling contracts in western North America and the relieving platform type of pier and bulkhead construction.

Wheeler, Walter H.—Building Settlement Checked Successfully. 1939. (Engineering News-Record, October 26, p. 531–533.) Continuing settlement of a large school building was successfully checked by installation of an underground framework carried on steel bearing piles outside the building walls.

White, Lazarus.—Supporting Subways in New York. 1932. (Civil Engineering, March, p. 141–144.) Accurate determination of the stresses to be withstood by the foundations and floors of subways and their proper design, special reference to waterproofing and groundwater pressures.

White, Lazarus, and Paaswell, George.—Lateral Earth and Concrete Pressures. 1939. (Transactions, ASCE, Vol. 104, p. 1685–1700.) Discussion, p. 1701–1732. New methods based on fundamental laws of theory of elasticity as has been done in finding distribution of vertical pressures. Divided into three phases with equations and tables.

Wilcoxen, L. C.—New Pile-Bearing Formula from Model-Pile Tests. 1932. (Engineering News-Record, November 3, p. 524–526.) Tests of model piles indicate bearing power characteristics of different shapes in sand and clay and suggest new pile-bearing formula. Two typographical errors pointed out, December 29, p. 787.

Williams, Charles P.—Foundation Treatment at Rodriguez Dam. 1934. (Transactions, ASCE, Vol. 98, p. 295–305.) Discussion, p. 306–313. An account of the design and construction of the foundation structure. Dam is of the Ambursen type, greater in height than any of that type heretofore built. Bed-rock in parts of stream bed is of inferior quality, and, in some parts, disintegrated.

Williams, C. C.—Small Earth Vibrations Affect Foundations. 1932. (Civil Engineering, November, p. 675–679.) Structural significance of jars produced by blasting, pile driving, traffic, rotating machinery and subways recorded and studied. Settlement caused by vibrations.

Williams, Neil.—Rotary Rig Foundations in Gulf Coast Marshes. 1940. (Oil and Gas Journal, August 8, p. 42–43.) Newly designed piling foundation for drilling rigs used less piling and bracing reducing costs of building.

Wood Preserving News.—Creosoted Piles Support Buildings in Government Housing Project. 1936. (Wood Preserving News, October, p. 116–119.) Slough necessitates pressure creosoted piles under foundation of power house and houses in slough area.

Yates, Joseph J.—Design and Construction of Bridge Foundations. 1932. (Civil Engineering, March, p. 144–146.) Necessary steps in making an investigation for the design of a bridge foundation. Importance in design of construction methods to be followed. Concrete deposited under water, even carefully, too often gives poor results.

Yorke, Dudley.—Economics of Geology as Applied to Engineering. 1931. (Engineering and Contracting, December, p. 323–326.) Knowledge of geology often invaluable to civil engineer in connection with special branches in his line of work. Discusses relation with various problems including foundations.

Report on Assignment 6

Methods and Practices of Lining and Relining Tunnels

Collaborating with Committee 1—Roadway and Ballast

I. L. Pyle (chairman, subcommittee), G. E. Boyd, Maurice Coburn, G. F. Eberly, A. C. Irwin, W. A. Kingman, Roscoe Owen, O. V. Parsons, G. R. Smiley.

Last year the committee presented as information, Specifications for Lining Railway Tunnels with Metal Liner Plates and Shotcrete. The committee now presents these specifications in the same form in which they appear in Volume 42, Proceedings for 1941, pp. 307 to 309, together with insert, properly designated, showing Method of Lining Tunnels with Shotcrete on Liner Plates, for publication in the Manual, with one change only, which is as follows:

101. Scope

These specifications cover the lining of new tunnels and the relining of old tunnels through ordinary formations which involve no special features. In the lining of new, or unlined tunnels, they are intended principally for preventing disintegration of the natural surface due to atmospheric conditions; and in old, lined tunnels, to preserve the existing lining.

In 1940, your committee submitted as information Specifications for Lining Railway Tunnels with Brick. These specifications are now re-submitted below with the recommendation that they be adopted for publication in the Manual. As presented here, they are in exactly the same form as they appeared in the Proceedings for 1940, pages 373–377, inclusive, except that paragraph 9 has been revised.

SPECIFICATIONS FOR LINING RAILWAY TUNNELS WITH BRICK

I GENERAL

Scope

1. These specifications cover the lining of new tunnels and the relining of old tunnels through ordinary formations which involve no special features.

II MATERIALS

Brick

2. Brick shall be vitrified, size approximately 3 inches by 4 inches by 8½ inches. The brick shall have a crushing strength of not less than 6,000 pounds per square inch and, when broken in two parts and immersed in water for 24 hours, shall not absorb in excess of 3 percent by weight.

Mortar

3. Mortar shall be composed of 1 part Portland cement, and approximately ½ part dry lime hydrate or an equivalent amount of lime putty, and 5 parts sand, measured by loose volume.

Cement

4. Cement for mortar shall meet the requirements of the AREA Specifications for Portland cement. Cement that has hardened or partially set shall not be used.

Lime

5. Hydrated lime (or lime putty) shall meet the requirements of the ASTM "Hydrated Lime for Structural Purposes," Designation C–6–34T, and shall be sampled and tested according to ASTM "Standard Methods of Sampling, etc." Designation C–50.

Sand

6. Sand shall consist of fine granular material composed of hard, strong, durable mineral particles, free from injurious amounts of saline, alkaline, organic, or other deleterious substances. The amount of deleterious substances shall not exceed 3 percent. It shall be graded uniformly from fine to coarse within the limits specified by the Engineer, and contain a sufficient quantity of finer sizes to give suitable workability.

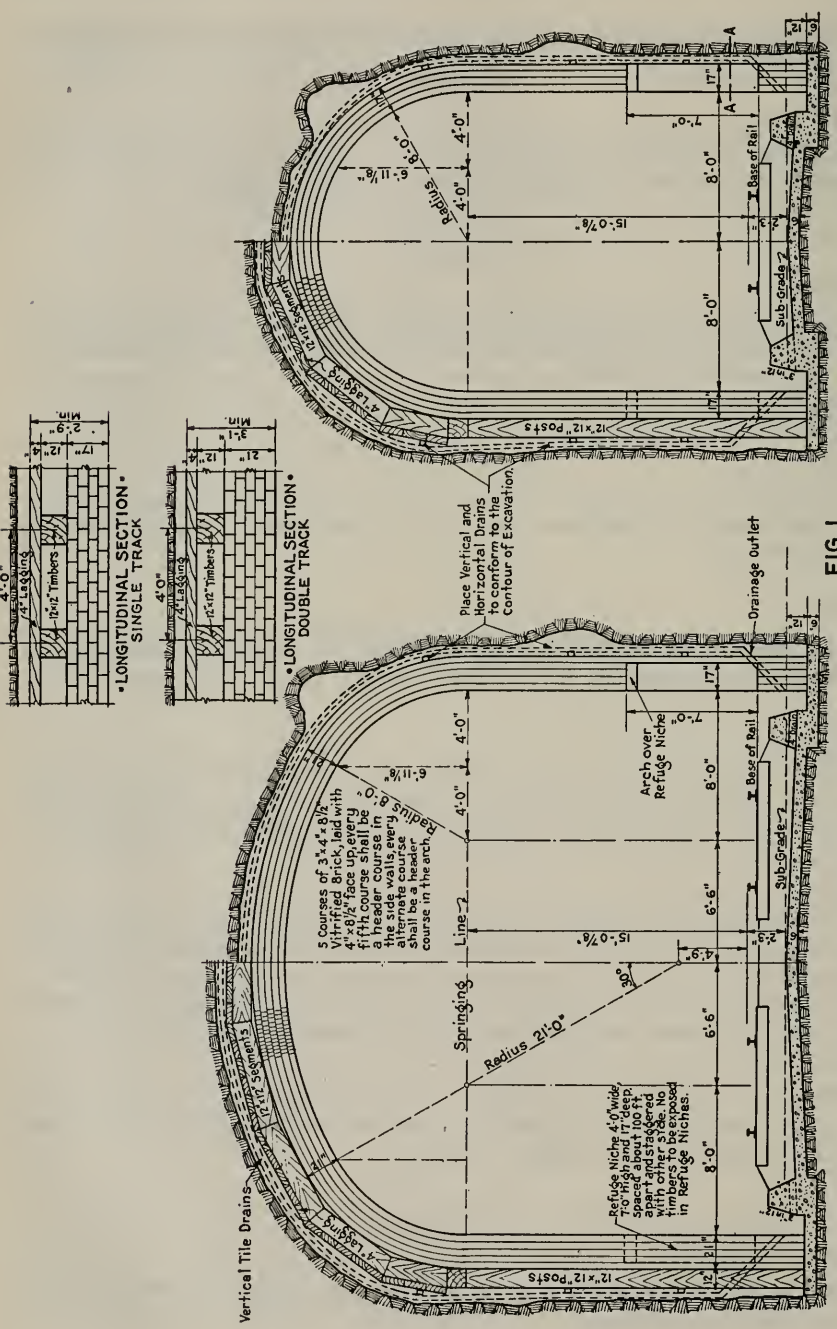
Water

7. The water shall be clean, reasonably clear, and free from oil, acid and injurious amounts of vegetable matter, alkalies or other salts.

III DESIGN

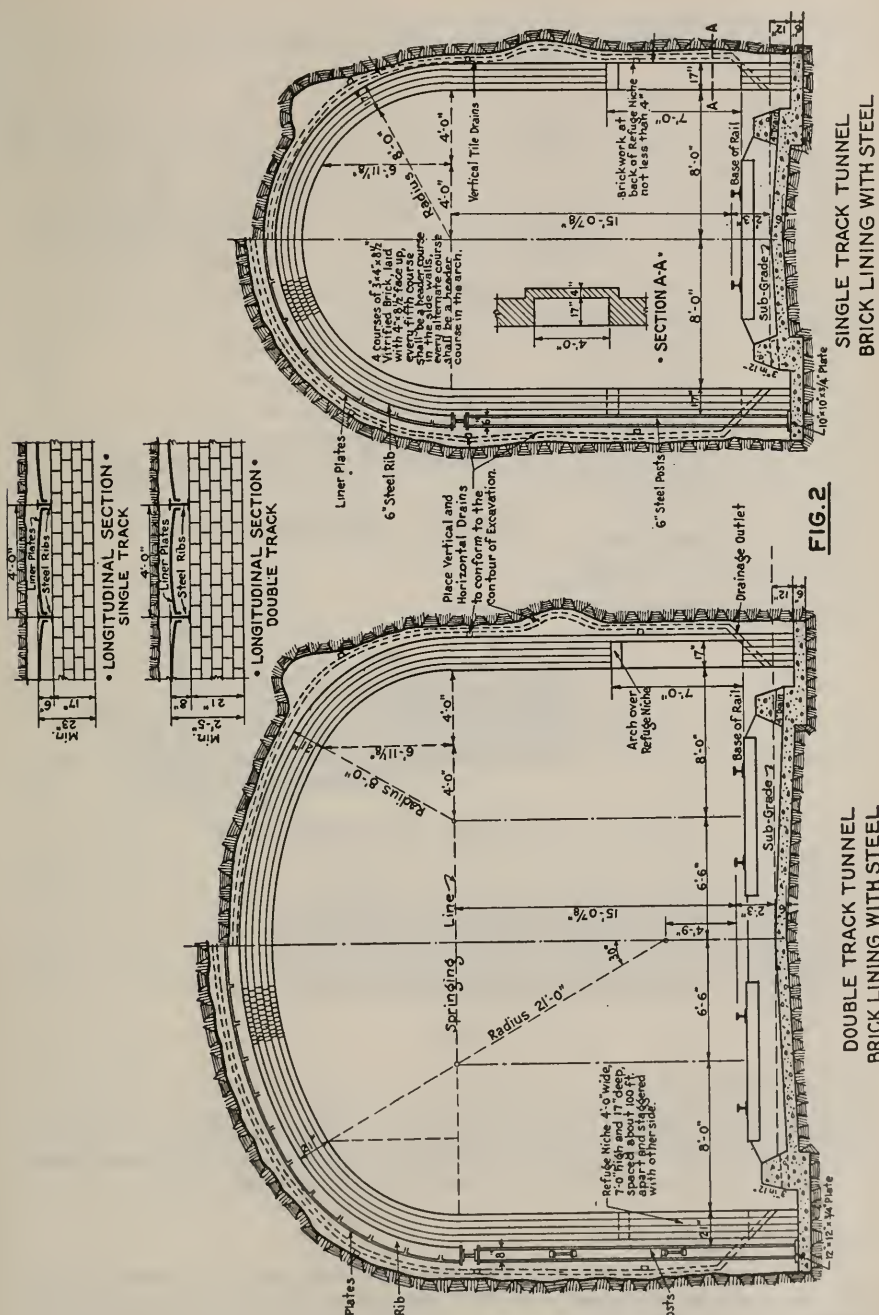
Interior Dimensions

8. The interior dimensions shall be not less than required by AREA standard clearance diagrams for tunnels.



SINGLE TRACK TUNNEL
BRICK LINING WITH TIMBERS
DOUBLE TRACK TUNNEL
BRICK LINING WITH TIMBERS
Place Vertical and Horizontal Drains to conform to the Contour of Excavation.
Drainage Outlet
Arch over Refuge Niche
Base of Rail
Sub-Grade
Radius 8'-0"
Radius 21'-0"
Springing Line
5 Courses of 3"x4"x8½" Vitrified Brick, laid with 4"x8½" face up, every fifth course shall be a header course in the side walls, every alternate course shall be a header course in the arch.
Refuge Niche 4'-0" wide, 7'-0" high and 17" deep. Spaced about 100 ft. apart and staggered with other side. No timbers to be exposed in Refuge Niches.
12"x12" Posts
4" Lagging
12"x12" Segments
Vertical Tile Drains
•LONGITUDINAL SECTION• SINGLE TRACK
•LONGITUDINAL SECTION• DOUBLE TRACK
4'-0"
12"x12" Timbers
4" Lagging
2'-9" Min.
3'-1" Min.

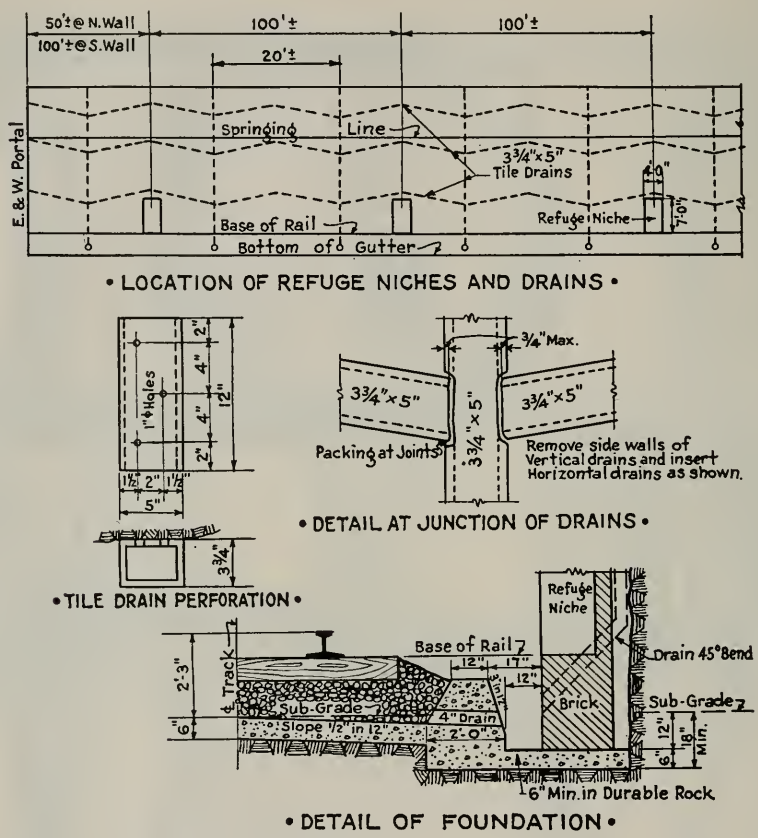
FIG. 1



SINGLE TRACK TUNNEL
BRICK LINING WITH STEEL

DOUBLE TRACK TUNNEL
BRICK LINING WITH STEEL

FIG. 2



NOTE-
On double track where centers are more than 13 ft., increase distance between sidewalls accordingly. On curved track the clearances shall be increased to allow for the overhang and the tilting of a car 80 ft. long, 60 ft. between centers of trucks and 14 ft. high. The super elevation of the outer rail shall be in accordance with the recommended practice of the A.R.E.A.

Fig. 3.

Floor and Ballast Walls

9. In all new tunnels, a concrete floor and ballast walls for ballast track section, or a floor for solid track section, shall be installed in accordance with AREA Specifications for Lining Railway Tunnels with Plain Concrete, page 8–103 of the Manual.

Foundation for Side Walls

10. A concrete footing shall be provided for the brick walls. The concrete shall be made and placed in accordance with the AREA Specifications for Portland Cement Concrete, Plain and Reinforced, and shall have a minimum compressive strength of 3,000 pounds per square inch in 28 days.

The bottom of the concrete footing, in hard, durable material, shall be at least 6 inches below the bottom of the gutter. In other material it shall be carried to suitable foundation (Figs. 1, 2 and 3).

Side Wall and Arches

11. In side walls, the bricks shall be laid with their 4 inch by 8½ inch face up, and every fifth course shall be headers, in the arch, every alternate course shall be headers. Joints shall be not less than ¼ inch and not over ½ inch thick. All joints must be filled solidly with mortar.

The thickness of the sidewalls and arch shall be not less than 17 inches for single track and not less than 21 inches for double track tunnel. At intervals of approximately 20 feet, the walls shall be tied back to the natural face of the tunnel by brick spandrel walls.

The space between the natural face of the tunnel and brick lining shall be filled with concrete or hard durable stone thoroughly rammed, or tamped into place. When it is necessary to temporarily support the face of the excavation with steel or timber supports, the space between the liner plates or lagging and the face of the excavation shall be firmly packed with hard durable stone rammed into place, or sand placed pneumatically. The space between the lagging or liner plates and the brick lining shall be filled with concrete, or hard durable stone thoroughly rammed or tamped into place.

Arch centers shall be slacked—not struck—immediately after keying so that mortar may harden under slight pressure.

Drainage Openings

12. Vertical and diagonal openings, French drains, or 3¾ inches by 5 inches rectangular tile drains shall be installed as necessary in the rear of the lining, with outlets through the sidewalls to provide adequate drainage.

Weep holes shall be placed through the sidewalls at intervals of 20 feet unless drainage conditions require them placed at shorter intervals. The weep holes should be of pipe not less than 4 inches in diameter and placed on a slope of 45 degrees. The outer end of the outlets or weep holes shall be not less than 12 inches above the bottom of the gutter. Sub-drains shall be provided under the floor as necessary. Four-inch round tile drains or openings of similar area shall be installed in each 10 feet of ballast walls to provide drainage for the section of the floor between the ballast walls (Fig. 1 and 2).

Refuge Niches

13. Refuge niches shall be at least 17 inches deep, 4 feet wide and 7 feet high. In single track tunnels the brickwork at back of niches should be not less than 1 course thick. Niches should be spaced approximately 100 feet apart and staggered with opposite side so that niches will occur every 50 feet in the tunnel. The bottom of niches shall be at the elevation of base of rail.

Report on Assignment 10

Pressure Grouting

W. M. Ray (chairman, subcommittee), H. E. Burr, F. W. Capp, Maurice Coburn, G. F. Eberly, A. C. Irwin, W. A. Kingman, Roscoe Owen, O. V. Parsons, I. L. Pyle, G. E. Robinson.

Last year your committee presented as information (Proceedings for 1941, Vol. 42, pages 319–320), Specifications for Solidification of Masonry Structures by Pressure Grouting, and requested comments and criticisms thereon. These specifications (with a minor revision) are now submitted with the recommendation that they be adopted and published in the Manual. The revision is as follows:

Substitute for 3 (a): The cement shall comply with AREA Specifications for Portland Cement, Manual pages 8–9, ASTM C 150–41.

Your committee is not prepared at this time to submit specifications for the solidification of soils under foundations or of materials behind tunnel linings and subway walls. However, considerable information on these subjects has been accumulated and is under consideration as a basis for formulating specifications. In this connection your committee offers as information a description of grouting the Chicago subway tunnels furnished by Mr. A. C. Irwin, assistant subway engineer, Department of Subways and Superhighways, City of Chicago.

Grouting the Chicago Subway Tunnels

By A. C. Irwin

Assistant Subway Engineer, Department of Subways and Superhighways, City of Chicago

Pressure grouting of the Chicago subway tunnels has been done for two principal purposes; namely, to fill voids between the concrete and the liner plates, or between the liner plates and the clay, and to stop leakage into the completed tunnel.

All of the initial system of Chicago's subways is built in clay with the exception of a very small amount of deeper construction under and approaching the Chicago river, where some hard pan was encountered. The tunnels were all driven under compressed air, and a rib-and-liner-plate system was used with a bench method of excavating, except for the portion in the downtown "loop", where a shield was employed with heavy segments of flanged liner plates following the shield to hold the clay. The ribs and liner plates, and also the shield, fixed the cross section of the tunnels; but overmining often happened with the ribs and plates and the excavation was always larger than the lining by the thickness of the shield. In order to prevent settling of the clay to fill the spaces thus left, with consequent settlement of the street surface, roofing gravel was blown through holes in the liner plates into the voids behind these plates, which were left in place. As a further precaution against settlement and to prevent loss of air pressure before the concrete lining was placed, low pressure grouting was done with a 1 : 1 mix under a pressure of approximately 25 lb. per sq. in.

Grouting pipes were set for use after the concrete had been placed. These grouting pipes registered with the holes through the liner plates, so that the grout could pass

behind the liner plates to fill voids in the roofing gravel packing, as well as to fill any spaces left between the concrete and the liner plates. These grouting pipes were at the crown of the arch.

The roofing gravel was started under an air pressure of 100 to 125 lb., but as the gravel particles did not fill the delivery hose, they were transported in a current of air rather than being blown by the air pressure used. Filling of the spaces behind the liner plates was therefore accomplished largely by gravity.

After the concrete had hardened, pneumatic grouting was done through the grout pipes, using grout of the proportions of about 1 cement to 1 sand or 1 cement to 2 sand until refusal under a pressure of approximately 50 lb. per sq. in. In locations where the presence of voids became known to the inspecting engineer, or where they were disclosed by borings, extra holes were drilled through the lining and the grouting continued to refusal. The spacing of these holes was determined as the work of drilling and grouting progressed. After the completion of the tunnels, further grouting was done to stop leakage through construction joints and occasionally through construction cracks.

The grouting holes were 1¾ in. diameter, drilled with air percussion drills. The grout consisted of various proportions of cement, "mineral filler" and "Intrusion Aid," depending on information obtained from drilled holes and preliminary grouting operations. The grout was pumped by a small duplex water pump, and pressures up to 150 lb. per sq. in. at the pump were used, with occasional pressures as high as 350 lb. per sq. in.

The results of these various operations were, in general, successful. Nearly 500 cores were bored through the concrete and liner plates, and gravel packing was encountered in nearly every case where the liner plate was not against the clay. However, the grout did not penetrate the gravel packing to any considerable extent. Grouting was in most cases effective in filling spaces remaining at the crown after the concrete was placed, although there were exceptions. Re-grouting was always done where spaces were found. The grouting for waterproofing was also successful to a very great degree, although not 100 percent. The leakage into the tunnels has been reduced to a point where it may be easily handled.

Report on Assignment 11

Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures

C. H. Splitstone (chairman, subcommittee), G. H. Dayett, Meyer Hirschthal, A. C. Irwin, M. L. Johnson, J. E. Kalinka, J. A. Lahmer, A. N. Laird, C. P. Marsh, J. L. Rippey, F. B. Robins, G. E. Robinson, C. P. Schantz, G. E. Shaw, F. R. Smith, L. I. Stone, W. R. Wilson, J. J. Yates.

This report is presented with the recommendation that the specifications contained herein be published as information and that the subject be continued to enable the committee further to revise and improve the specifications with the intention that they be presented for inclusion in the Manual at a later date.

Last year the report on Assignment 14 embraced Specifications for Concrete Placed Under Water. This year Specifications for Portland Cement are being presented in the

report of another subcommittee. These two subsidiary specifications have not been recognized in the specifications presented herein, but will be consolidated with these specifications in due time.

It has been the purpose of your committee to include in the specifications only such material as may appropriately be included as a part of a contract for Portland cement concrete for railroad structures. It is also the purpose of this committee to continue work on the preparation of recommended practices which will run parallel with the specifications and will contain such information as will be of value to the engineer in design or in the consideration of special problems, but will not be necessarily included in the usual form of contract, but which will be proposed for inclusion in the Manual.

SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE RAILROAD BRIDGES AND OTHER STRUCTURES

I MATERIALS

Aggregates

101. Sampling and Testing

Sampling and testing shall be in accordance with the following standard methods of the American Society for Testing Materials:

(a) Sampling	Designation	D 75—40	T
(b) Sieve Analysis	"	C 136—39	
(c) Weight of Aggregates	"	C 29—39	
(d) Resistance to Abrasion	"	C 131—39	
(e) Soundness	"	C 88—39	T
(f) Material Passing No. 200 Sieve	"	C 117—37	
(g) Mortar Strength	"	C 87—39	
(h) Organic Impurities	"	C 40—33	
(i) Combustible and Volatile Materials	"	D 271—40	
(j) Slump Test	"	C 143—39	

The fineness modulus of the aggregates shall be the sum of the percentages coarser than each sieve divided by 100, using the following standard sieve sizes: No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, ⅜ inch, ¾ inch, 1½ inch, 3 inch.

102. Soundness

The aggregates when subjected to five alternations of the sodium-sulfate soundness tests shall show an average loss of weight of not more than 8 percent for fine aggregate and 12 percent for coarse aggregate.

Fine Aggregates

103. General

Fine aggregate shall consist of natural sand or, subject to the approval of the Engineer, other inert materials with similar characteristics. Representative samples shall be selected and sent to the testing laboratory at frequent intervals as directed by the Engineer. Fine aggregate may not be used until the samples have been approved by the designated laboratory as being in conformity with the following requirements and its use is authorized by the Engineer.

104. Grading

Fine aggregate shall be graded from coarse to fine within the limits shown in the following table:

Sieve Size	*Total Passing Percentage by Weight* *Minimum*	*Maximum*
⅜-inch	100	
No. 4	95	100
No. 16	45	80
No. 50	10	30
No. 100	0	8

For walls and other locations where smooth surfaces are desired, the fine aggregate shall be graded within the limits shown in the table above except that not less than 15 percent shall pass the No. 50 sieve and not less than 3 percent shall pass the No. 100 sieve.

105. Uniformity

For the purpose of controlling the grading, within the limits specified in Section 104, of fine aggregates from any one source, a preliminary sample shall be submitted at least 10 days prior to actual deliveries. This sample shall be representative of the material which it is proposed to furnish. Any shipment of fine aggregates made during the progress of the work which shows a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the preliminary sample shall be rejected or, at the option of the Engineer, may be accepted subject to such changes in concrete proportions as may be necessary by reason of failure to comply with the requirements of this Section.

106. Deleterious Substances

The amount of deleterious substances shall not exceed the following limits:

	Recommended Permissible Limits Percent by Weight	*Maximum Permissible Limits Percent by Weight*
Clay lumps	1	1.5
Coal and lignite	0.25	1
Material finer than No. 200 Sieve:		
(a) In concrete subject to surface abrasion	2	3
(b) All other classes of concrete	3	5
Other deleterious substances (As may be specified)	..	..

107. Organic Impurities

The fine aggregate when tested in accordance with the colorometric method of test for organic impurities shall show a color not darker than the standard color unless the material complies with the mortar strength test specified in Section 108.

108. Mortar Strength

Fine aggregate shall be of such quality that when made into a mortar and subjected to the mortar strength test in accordance with the ASTM Standard Method of Test for Structural Strength of Fine Aggregate, Using Constant Water-Cement-Ratio Mortar, it shall develop a compressive strength of not less than that developed by a mortar prepared in the same manner with the same cement and Ottawa sand graded

as specified in ASTM C 109—37 T, when tested at an age of seven days when Type I or Type II Portland cement is used and three days when Type III Portland cement is used.

Coarse Aggregate

109. General

Coarse aggregate shall consist of crushed stone, gravel, or, subject to the approval of the Engineer, other inert materials with similar characteristics, or combinations thereof, having hard, strong, durable pieces, free from adherent coatings and shall conform to the requirements of this specification.

Crushed slag, if permitted, shall be air cooled, blast furnace slag and shall weigh not less than 70 pounds per cubic foot.

110. Grading

Coarse aggregate shall be well graded, between the limits specified, and the size or sizes designated shall conform to the following requirements:

Designated Sizes	Percentage by Weight Passing Laboratory Sieves Having Square Openings										
	4 in.	3-1/2 in.	2-1/2 in.	2 in.	1-1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8
No. 4-1/2"	.	..	.	..	..	..	100	90-100	40-75	0-15	0-5
No. 4-3/4"	.	..	.	..	..	100	90-100	..	20-55	0-10	0-5
No. 4-1"	.	..	.	..	100	90-100	..	25-60	.	0-10	.
No. 4-1 1/2"	.	..	.	100	95-100	..	35-70	..	10-30	0-5	.
No. 4-2"	.	..	100	95-100	..	35-70	..	10-30	.	0-5	.
3/4-1 1/2"	.	..	.	100	90-100	20-55	0-15	..	.	.	.
1/2"	.	..	100	90-100	35-70	0-15	..	..	.	.	.
2-3 1/2"	100	90-100	.	0-15	..	..	..	..	.	.	.

The maximum size aggregate shall be not larger than one-fifth of the narrowest dimension between forms of the member for which the concrete is used, nor larger than one-half of the minimum clear space between reinforcing bars.

111. Abrasion Loss

Crushed stone or gravel to be used in concrete subject to surface abrasion shall meet the following requirements for abrasion loss:

Material	*Maximum Loss, Percent by Weight*
Crushed stone	5
Gravel, uncrushed	10
Gravel, 100 percent crushed	20
Gravel, ... percent crushed	..

112. Fireproofing Aggregate

Aggregates meeting the requirements of Sections 101 to 111, inclusive, of these specifications are suitable for use in fireproof construction. When used in fireproof construction they shall be divided into two groups as follows:

Group 1.—Blast-furnace slag, limestone, calcareous gravel, trap rock, burnt clay or shale, cinders containing not more than 25 percent of combustible material and not more than 5 percent of volatile material, and other materials meeting the requirements of these specifications and containing not more than 30 percent of quartz, chert, flint, and similar materials.

Group 2.—Granite, quartzite, siliceous gravel, sandstone, gneiss, cinders containing more than 25 percent, but not more than 40 percent of combustible material and not more than 5 percent of volatile material and other materials meeting the requirements of these specifications, and containing more than 30 percent of quartz, chert, flint and similar materials.

The Engineer will show on the drawings where each of the above groups of aggregates are required.

113. Rubble Aggregate

Rubble aggregate shall consist of clean, hard, durable stone or gravel retained on a six-inch square opening and with individual pieces weighing not more than 100 pounds.

114. Cyclopean Aggregate

Cyclopean aggregate shall consist of clean, hard, durable stone or gravel with individual pieces weighing more than 100 pounds.

Mixing Water

115. General

Water for concrete shall be clean and free from injurious amounts of oil, acid. alkali, organic matter, or other deleterious substances.

116. Mortar Strength

When subjected to the mortar strength test, the strength, at 28 days, of mortar specimens made with the water under examination and Type I or Type II Portland cement shall be at least 90 percent of the strength of similar specimens made with the same cement and with water of known satisfactory quality.

Metal Reinforcement

117. General

Metal reinforcement shall include plain and deformed steel bars and cold drawn steel wire or fabricated forms of these materials.

118. Quality

All steel bars used for reinforcement shall be of structural or intermediate grade billet-steel except for structures where all the steel bars are used for temperature reinforcement and do not carry calculated stresses, in which case rail or axle steel may be used. The materials shall conform in quality to the standard ASTM specifications of the following applicable titles and serial designations:

Bars:

Specifications for Billet-Steel Bars for Concrete Reinforcement ..... A 15–39
Specifications for Rail-Steel Bars for Concrete Reinforcement ..... A 16–35
Specifications for Axle-Steel Bars for Concrete Reinforcement ..... A 160–39

Wire:

Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement ... A 82–34

Fabricated Materials:

Specifications for Fabricated Steel Bar or Rod Mats for Concrete Reinforcement ..... A 184–37
Specifications for Welded Steel Wire Fabric for Concrete Reinforcement A 185–37

When cast iron or structural steel sections are used, as in composite or combination columns, these materials shall conform in quality to the standard ASTM specifications of the following applicable titles and serial designations:

Specifications for Cast-Iron Pit-Cast Pipe for Water and Other Liquids A 44–39T
Specifications for Steel for Bridges and Buildings ..... A 7–39

119. Deformed Bars

An approved deformed bar shall be one that will develop a bond at least 25 percent greater than that of a plain round bar of equivalent cross sectional area. The minimum area of deformed bars shall be not less than that of plain bars of same nominal dimensions.

120. Size of Bars

Reinforcing bars shall have minimum section areas not less than shown in the following table, and the unit weights shown in this table shall be used in computing weights:

SIZES AND AREAS OF REINFORCING BARS

Size of Bar	Round Bars		Square Bars	
Inches	Area Square Inches	Weight Per Foot	Area Square Inches	Weight Per Foot
1/4	.0491	.167	..	..
3/8	.1104	.376	..	..
1/2	.1963	.668	.2500	.850
5/8	.3068	1.043	..	..
3/4	.4418	1.502	..	..
7/8	.6013	2.044	..	..
1	.7854	2.670	1.000	3.400
1-1/8	..	..	1.2656	4.303
1-1/4	..	..	1.5625	5.312

Cement

121. Quality and Methods of Sampling and Testing

The quality of cement and the methods of sampling and testing it shall be as required by AREA Specifications For Portland Cement, pages 8–9 of the Manual, and by the various methods of sampling and testing portland cement, published on following pages of the Manual, or any current revisions thereof.

II WORKMANSHIP

Proportioning

201. General

Concrete for all purposes shall be composed of cement, natural or crushed aggregates, and water of the qualities herein specified. These ingredients shall be well mixed and brought to a proper consistency. The proportions in which these materials are to be used for different parts of the work shall be determined by the Engineer from time to time during the progress of the work as analyses and tests are made of samples of the aggregate and the resulting concrete. In general the proportions shall be designed to produce a concrete of maximum practical economy to the Owner.

202. Measurement of Materials[1]

In the measurement of cement, 94 pounds, one sack, or one-quarter barrel shall be assumed as one cubic foot.

Materials shall be measured by weighing, except as otherwise specified or where other methods are authorized specifically by the Engineer. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. The coarse aggregate, fine aggregate and cement shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount. Cement in standard packages (sacks) need not be weighed, but bulk cement and fractional packages shall be weighed. The mixing water shall be measured by volume or by weight. The water-measuring device shall be susceptible to control accurate to plus or minus ½ percent. All measuring devices shall be subject to approval by the Engineer.

Where volumetric measurements are authorized by the Engineer, the weight proportions shall be converted to equivalent volumetric proportions. In making this conversion, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregate.

203. Water Cement Ratio

The proportioning of materials shall be based on the requirements for a plastic and workable mix containing not more than the specified amount of water, including water contained in the aggregate, per 94-pound sack of cement. The maximum specified amount of water shall be as shown in the Table I for the type of structure and the condition of exposure to which it will be subjected. Moisture in the aggregate shall be measured by methods satisfactory to the Engineer.

These quantities of water must not be exceeded. Free water content of the aggregates is included in the quantities specified and must be deducted from the amounts given in the table, to determine the amount to be added at the mixer. Allowance may be made for absorption when aggregates are not saturated.

204. Assumed Strength of Concrete Mixtures

Concrete made with Type I or Type II Portland cement with the quantities of water as specified in Section 203 is assumed to have the following minimum compressive strength at the age of 28 days:

Total Water U. S. Gallons per 94 lb. Sack of Cement	*Assumed Minimum Compressive Strength at the Age of 28 Days lb. per sq. in.*
8	2,250
7	2,750
6½	3,000
6	3,300
5½	3,700
5	4,250

The above values are based on the use of cement and aggregates meeting the requirements of these specifications and the concrete being sufficiently protected from loss of moisture and from low temperatures to insure that proper hardening will develop. When Type III Portland cement is used in lieu of Type I or Type II Portland cement, it is assumed the above values for compressive strength will be obtained at the age of 7 days.

[1] The Canadian sack of cement weighs 87½ pounds, and the Imperial gallon 1.2 equals U. S. gallons. This should be recognized in specifying the water cement ratio in these units.

TABLE I - WATER CONTENTS SUITABLE FOR VARIOUS CONDITIONS OF EXPOSURE (Gal. per sack of cement)

Type or Location of Structure	Severe or Moderate Climate, Wide Range of Temperatures, Rain and Long Freezing Spells or Frequent Freezing and Thawing					Mild Climate, Rain or Semi-Arid, Rarely Snow or Frost				
	Thin Sections		Moderate Sections		Heavy and Mass Sections	Thin Sections		Moderate Sections		Heavy and Mass Sections
	Reinf.	Plain	Reinf.	Plain		Reinf.	Plain	Reinf.	Plain	
A. At the waterline in hydraulic or waterfront structures or portions of such structures where complete saturation or intermittent saturation is possible, but not where the structure is continuously submerged:										
In Sea Water.	5	5-1/2		6		5	5-1/2		6	
In Fresh Water.	5-1/2	6		6-1/2		5-1/2	6		6-1/2	
B. Portions of hydraulic or waterfront structures some distance from the waterline, but subject to frequent wetting:										
By Sea Water.	5-1/2	6		6		5-1/2	6-1/2		7	
By Fresh Water.	6	6-1/2		6-1/2		6	7		7-1/2	
C. Ordinary exposed structures, buildings and portions of bridges not coming under above groups.	6	6-1/2		7		6	7		7-1/2	
D. Complete and continuous submergence:										
In Sea Water.	6	6-1/2		7		6	6-1/2		7	
In Fresh Water.	6-1/2	7		7-1/2		6-1/2	7		7-1/2	
E. Concrete deposited through water:	*	*	5-1/2	5-1/2		*	*	5-1/2	5-1/2	
F. Pavement slabs directly on ground:										
Wearing slabs.	5-1/2	6	*	*		6	6-1/2	*	*	
Base slabs.	6-1/2	7	*	*		7	7-1/2	*	*	
G. Special cases:										
(a) For concrete exposed to strong sulfate ground waters, or other corrosive liquids or salts, the maximum water content should not exceed 5 gal. per sack.										
(b) For concrete not exposed to the weather, such as the interior of buildings and portions of structures entirely below ground, no exposure hazard is involved and the water content should be selected on the basis of the strength and workability requirements.										

* These sections not practicable for the purpose indicated.

205. Workability

The concrete shall be of such consistency and composition that it can be worked readily into the corners and angles of the forms and around the reinforcement without permitting the materials to segregate or free water to collect on the surface. Subject to the limiting requirements of Section 203 the Contractor shall, if the Engineer approves, adjust the proportions of cement and aggregates as may be necessary to produce a

mixture which will be easily placeable at all times, due consideration being given to the methods of placing and compacting used on the work.

206. Slump

The slump test may be used as a control measure to maintain a consistency suitable to the work. When mechanical vibrators are used to compact the concrete, the consistency shall be suitable to that method of compacting.

207. Water Gain

As soon as an overwet condition arises in the concrete through water gain, the succeeding batches of concrete must be placed sufficiently dry to correct the overwet condition. In such cases, for corrective purposes only, the concrete shall be made drier by reducing the amount of water per bag of cement without changing the proportions of the other ingredients used.

208. Compression Tests

Specimens for compression tests shall be made and stored in accordance with the ASTM Standard Method of Making and Storing Compression Test Specimens of Concrete in the Field (Serial Designation C 31–39). These specimens shall be tested in accordance with ASTM Standard Method of Test for Compressive Strength of Concrete (Serial Designation C 39–39).

Mixing

209. Equipment

The mixing equipment shall be capable of combining the aggregates, cement, and water within the specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.

210. Machine Mixing (at Site or at Central Mixing Plant)

Unless otherwise authorized by the Engineer, the mixing of concrete shall be done in a batch mixer of approved type and size which will insure a uniform distribution of the material throughout the mass. The equipment at the mixing plant shall be so constructed that all materials (including the water) entering the drum can be accurately measured and weighed and be under control. The entire batch shall be discharged before recharging. The volume of the mixed material per batch shall not exceed the manufacturer's rated capacity of the mixer. Except as qualified in Section 212, mixing of each batch shall continue for the periods indicated below[2] during which time the drum shall rotate at a peripheral speed of about 200 feet per minute. The mixing periods shall be measured from the time when all of the solid materials are in the mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed.

Mixing time shall be as follows:

1. For mixers of a capacity of one cubic yard or less—1½ minutes.
2. For mixers of capacities larger than one cubic yard, the time of mixing shall be increased 15 seconds for each additional half cubic yard capacity or fraction thereof.

[2] When, in the judgment of the Engineer, longer mixing times are necessary he should so specify.

211. Truck Mixing

Truck mixers shall be watertight and so constructed that the concrete can be mixed to insure a uniform distribution of materials throughout the mass and, unless otherwise authorized by the Engineer, shall be of the revolving drum type. All solid materials for the concrete shall be accurately measured in accordance with Section 202 and charged into the drum at the proportioning plant. Except as subsequently provided, the truck mixer shall be equipped with a tank for carrying mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank is equipped with a device by which the quantity of water added to the concrete can be readily verified. The mixing water may be added directly to the batch, in which case a tank shall not be required. Truck mixers may be required to be provided with means by which the mixing time can be readily verified by the Engineer. The maximum size of batch in truck mixers shall be in accordance with the specified rating. Truck mixing shall be continued for not less than 50 revolutions after all ingredients, including the water, are in the drum. The speed shall not be less than 4 r.p.m., nor more than a speed resulting in a peripheral velocity of the drum of 225 feet per minute. Not more than 150 revolutions of mixing shall be at a speed in excess of 6 r.p.m. Mixing shall begin within 30 minutes[3] after the cement has been added either to the water or aggregate.

212. Partial Mixing at the Central Plant

When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation, the mixing time at the stationary machine mixer may be reduced to 30 seconds and the mixing completed in a truck mixer or agitator. The mixing time in the truck mixer or agitator equipped with adequate mixing blades shall be as specified for truck mixing in Section 211.

213. Time of Hauling Ready-Mixed Concrete

Concrete transported in a truck mixer, agitator, or other transportation device shall be discharged at the job within 45 minutes after the cement has been added to the water or the aggregates. The maximum volume of mixed concrete transported in an agitator shall be in accordance with the specified rating.

214. Hand Mixing

When hand mixing is authorized it shall be done on a watertight platform in batches limited to ⅓ cubic yard, and in such a manner as to insure a uniform distribution of the materials throughout the mass. Mixing shall be continued until a homogeneous mixture of the required consistency is obtained.

215. Retempering

The retempering of concrete or mortar which has partially hardened, that is, mixing with or without additional cement, aggregate, or water, will not be permitted.

Depositing Concrete in Air

216. General

Before beginning placement of concrete, hardened concrete and foreign materials shall be removed from the inner surfaces of the mixing and conveying equipment. Before depositing any concrete all debris shall be removed from the space to be occupied by

[3] When cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above 90 degrees F., or when Type III Portland cement is used, this limit shall be reduced to 15 minutes; the limitation on time between the introduction of the cement to the aggregates and the beginning of the mixing may be waived when, in the judgment of the Engineer, the aggregates are sufficiently free from moisture, so that there will be no harmful effects on the cement.

the concrete and accumulations of mortar splashed upon the reinforcement and surfaces of forms shall be removed, and forms shall be thoroughly oiled. Reinforcement shall be thoroughly secured in position and approval of the Engineer obtained. Where concrete is to be placed on a rock foundation, all loose rock, clay, mud, etc., shall be removed from the surface of the rock. Water shall be removed from the space to be occupied by the concrete before concrete is deposited, unless otherwise directed by the Engineer. Any flow of water into an excavation shall be diverted through proper side drains to a sump, or be removed by other approved methods which will avoid washing the freshly deposited concrete. If directed by the Engineer water ventpipes and drains shall be filled by grouting or otherwise after the concrete has thoroughly hardened.

217. Handling and Placing

Concrete shall be handled from the mixer, or in the case of ready mixed concrete from the transporting vehicle, to the place of final deposit as rapidly as practicable by methods which will prevent the separation or loss of the ingredients. It shall be deposited in the forms as nearly as practicable in its final position to avoid rehandling and shall not be dropped more than four feet unless otherwise permitted by the Engineer. It shall be so deposited as to maintain, until the completion of the unit, a plastic surface approximately horizontal, except in arch rings. Forms for walls or other thin sections of considerable height shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will avoid accumulations of hardened concrete on the forms or metal reinforcement. Under no circumstances shall concrete that has partially hardened be deposited in the work.

In placing concrete for an arch ring, the work shall be carried on symmetrically with respect to the center line and the working faces of the completed courses shall be on approximately radial planes. This requirement applies whether or not the arch is poured in voussoir sections with allowance for key sections for final pours.

218. Chuting

When concrete is conveyed by chuting, the plant shall be of such size and design as to insure a practically continuous flow in the chute. The chutes shall be of metal or metal lined. The angle of the chute with the horizontal and the shape of the chute shall be such as to allow the concrete to flow without separation of the ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. When the operation is intermittent, the chute shall discharge into a hopper. The chute shall be thoroughly flushed with water before and after each run; the water used for this purpose shall be discharged outside the forms. Chutes must be properly baffled or hooded at the discharging end to prevent separation of the aggregates.

219. Pneumatic Placing

Where concrete is conveyed and placed by pneumatic means the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The discharge lines shall be horizontal or inclined upwards from the machine.

At the conclusion of placement the entire equipment shall be thoroughly cleaned.

220. Pumping Concrete

The pump and all appurtenances shall be so designed and arranged that the specified concrete can be transported and placed in the forms without segregation. If piston type of pump is used, it shall be capable of developing a working pressure of at least

300 pounds per square inch and the pipe line and fittings shall be designed to withstand twice the working pressure. If the pump or machine is of the type in which delivery of concrete through the pipe is effected directly by air, there shall be available a working air pressure of 120 pounds per square inch. Sufficient air pressure shall be maintained; and, in some instances, a reservoir shall be installed in the air line so as to secure a continuous flow. A regulating valve shall be installed in the air line so as to control the pressure for variations in distance and height of placement.

Where concrete is conveyed and placed by mechanically applied pressure (piston type of pump), the operation of the pump shall be such that a stream of concrete without air pockets is produced. Where it is necessary to lay the pipe on a down grade, a reducer shall be placed at the discharge end of the pipe to provide a choke and thus produce a continuous flow of concrete. When the type of pump is such that it discharges the concrete in small batches, or by "belching", a baffle box shall be provided into which the concrete shall be discharged. This box should preferably be of metal, about two feet square, with open sides so as to permit the concrete to flow into the forms at right angles to line of discharge. The pipe shall be not less than 6 inches nor more than 8 inches outside diameter, and the line shall be laid with as few bends as possible. When changes in direction are necessary they should be made with bends of 45 degrees or less, unless greater bends are specifically permitted. If greater bends are permitted in special cases, they shall be long-radius bends. The maximum distance of delivery of concrete by pumping shall be 1,000 feet horizontally and 100 feet vertically, unless otherwise specifically permitted by the Engineer. (A 90-degree bend is figured as equivalent to 40 feet of horizontal piping. A 45-degree bend is equivalent to 20 feet. A 22½-degree bend is equivalent to 10 feet). When pumping is completed, the concrete remaining in the pipe line, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. The pipe line and equipment must then be thoroughly cleaned. The pipe line can be cleaned by either water or air. If water is used, a pump shall be provided with a capacity of at least 80 gallons per minute and capable of developing a pressure of 400 pounds per square inch. Cleaning of the pipe can also be accomplished by the use of a "go-devil" which is propelled through the line by water or air pressure. (The "go-devil" is a dumb-bell shaped piece with a cup rubber on each end. The cups are turned toward the liquid, or air, and the seal is the same as in a simple plunger pump.) If water is used, it must be discharged outside of the forms.

On important work duplicate pumping equipment and additional pipe shall be provided to prevent delay due to breakdown of equipment.

221. Compacting

Concrete, during and immediately after depositing, shall be thoroughly compacted by means of suitable tools. On exposed faces fine stone forks or spades shall be used to work the coarse aggregates back into the mass and allow the mortar and fine particles to occupy the space adjacent to the forms. For thin walls or inaccessible portions of the forms, where rodding or forking is impracticable, the concrete shall be assisted into place by tapping or hammering the forms opposite the freshly deposited concrete. The concrete shall be thoroughly worked around the reinforcement, and around embedded fixtures and into the corners of the forms.

High frequency vibration may be used in compacting the concrete. The consistency of the mixture and the period of vibration shall be such that the resulting concrete

will be free from segregation, honeycomb, or accumulations of water or laitance at the surface. The number and type of vibrators shall be subject to the approval of the Engineer.

222. Temperature

Concrete when deposited in massive structures, shall have a temperature of not less than 40 degrees F. nor more than 90 degrees F. When deposited in structures less than 6 feet in thickness, the following table for temperatures shall govern:

Temperatures of Air Degrees F.	*Temperature of Concrete When Placed Degrees F.*	
Below 30	70 Minimum	90 Maximum
Between 30 and 45	60 Minimum	90 Maximum
Above 45	50 Minimum	100 Maximum

The method of heating the materials shall be approved by the Engineer. The apparatus used shall heat the mass uniformly and preclude the occurrence of hot spots which would injure the materials.

When the climate is such that the temperature of the concrete coming from the mixer, without artificial heat, is higher than the maximum temperatures given above, the higher temperatures will be permitted if approved by the Engineer.

223. Continuous Depositing

Concrete shall be deposited continuously and as rapidly as practicable until the unit of operation, approved by the Engineer, is completed. Construction joints in addition to those provided on the plans will not be allowed unless authorized by the Engineer. If so authorized they shall be made in accordance with Section 247.

224. Bonding

Immediately before depositing new concrete on or against concrete which has hardened, the forms shall be tightened, the surface of the hardened concrete shall be roughened as required by the Engineer, thoroughly cleaned of foreign matter and laitance, and saturated with water. Excess water shall be removed so that the surface is wet but free from pools of water. The new concrete placed in contact with hardened or partially hardened concrete shall contain an excess of mortar to insure bond. To insure this excess mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and saturated surfaces of the hardened concrete, including vertical and inclined surfaces, shall first be slushed with a coating of neat cement grout against which the new concrete shall be placed before the grout has attained its initial set.

225. Placing Cyclopean Concrete

Cyclopean aggregate shall be thoroughly embedded in the concrete. The individual stones shall not be closer than 12 inches to any surface or adjacent stones. Stratified stone shall be laid on its natural bed. Cyclopean aggregate shall be carefully placed to avoid injury to forms or adjoining masonry.

226. Placing Rubble Concrete

Rubble aggregate shall be thoroughly embedded in the concrete. The individual stones shall not be closer than 4 inches to any surface or adjacent stones. Rubble aggregate shall be carefully placed to avoid injury to forms or adjacent masonry.

Curing

227. General

These Specifications for Heat Curing and Wet Curing are based on requirements when Type I or Type II Portland cement or Type III Portland cement is used in concrete deposited in air.

When moderate low-heat cement is used, the curing time herein specified shall be increased 25 percent.

When Type III Portland cement is used, the curing period shall be not less than 40 percent of that specified for Type I or Type II Portland cement.

228. Heat Curing

In freezing weather, or when there is likelihood of freezing temperatures within the specified curing period, suitable and sufficient means must be provided, before concreting, for maintaining all concrete surfaces at a temperature of not less than 50 degrees F. for a period of not less than 7 days after the concrete is placed when Type I or Type II Portland cement is used, and not less than 3 days when Type III Portland cement is used.

The temperature of concrete surfaces shall be determined by thermometers placed against the surface of the concrete. Provision shall be made in form construction to permit the removal of small sections of forms to accommodate the placing of thermometers against concrete surfaces at locations designated by the Engineer. After thermometers are placed, the apertures in forms shall be covered in a way to closely simulate the protection afforded by the forms.

In determining the temperatures at angles and corners of a structure, thermometers should be placed not more than 8 inches from the angles and corners. In determining temperatures of horizontal surfaces, thermometers shall rest upon the surface under the protection covering normal to section involved.

Temperature readings shall be taken and recorded at intervals to be designated by the Engineer, over the entire curing period specified, and the temperatures so recorded shall be interpreted as the temperature of the concrete surfaces where the thermometers were placed.

When protection from cold is needed to insure meeting these specification requirements, all necessary materials for covering or housing must be delivered at the site of the work before concreting is started and must be effectively applied or installed, and such added heat must be furnished as may be necessary without depending in any way upon the heat of hydration during the first 24 hours after concrete is placed when Type I or Type II Portland cement is used, or the first 18 hours when Type III Portland cement is used. The methods of heating and protecting the concrete shall be approved by the Engineer. Manure, if used for such protection, shall not come in contact with the concrete. Chemicals or other foreign materials shall not be mixed with the concrete for the purpose of preventing freezing.

When heat is supplied by steam or salamanders, covering or housing of the structure shall be so placed as to permit free circulation of air above and around the concrete within the enclosure, but to the exclusion of air currents from without, excepting that where salamanders are used, sufficient ventilation shall be provided to carry off gases. Special care shall be exercised to maintain the specified temperature continuously and uniformly in all parts of the structure enclosure, and to exclude cold drafts from angles and corners and from all projecting reinforcing steel. All exposed surfaces in the heated enclosure shall be kept continuously wet during the heated period unless heat is supplied in the form of live steam.

229. Wet Curing

When not otherwised specified, all concrete surfaces when not protected by forms, must be kept constantly wet for a period of not less than 7 days after concrete is placed when Type I or Type II Portland cement is used, and not less than 3 days when Type III Portland cement is used.

The wet curing period for all concrete which will be in contact with brine drip, sea water, salt spray, alkali or sulfate bearing soils or waters, or similar destructive agents, shall be increased to 50 percent more than the periods specified for normal exposures. Salt water and corrosive waters and soils shall be kept from contact with the concrete during placement and for a period of at least 3 days thereafter.

When wood forms are left in place during the curing period they shall be kept sufficiently damp at all times to prevent openings at the joints and drying of the concrete.

When wet curing is impracticable, liquid surface applications to prevent or minimize evaporation may be used in lieu of wet curing only when approved by the Engineer.

230. Field Tests

During the progress of construction the Engineer will have tests made to determine whether the concrete which is being produced compares to the quality specified in Section 204. The contractor shall cooperate in the making of such tests to the extent of allowing free access to the work for the selection of samples and storage of specimens and in affording protection to the specimens against injury or loss through his operations.

Three cylinders will generally be made for each class of concrete used in any one day's operation. In special cases this normal number of control specimens may be exceeded when in the opinion of the Engineer such additional tests are necessary. The contractor, however, shall not be required to furnish for such additional tests more than two cubic feet of concrete for each one hundred cubic yards of concrete being placed.

Samples of concrete for test specimens shall be taken at the mixer, or in the case of ready mixed concrete, from the transportation vehicle during discharge. When, in the opinion of the Engineer, it is desirable to take samples elsewhere, they shall be taken as directed by him. Such specimens shall be molded immediately after the sample is taken, placed in a protected spot and kept under moist curing conditions at approximately 70 degrees F. for 24 hours, whereupon they shall be removed to the testing laboratory.

Should the strengths shown by the test specimens fall below the values given in Section 204 the Engineer shall have the right to require changes in proportions to apply on the remainder of the work. Furthermore, the Engineer shall have the right to require additional curing up to, but not to exceed fourteen days.

Storage of Materials

231. Cement

Cement delivered in cars must be promptly stored in houses and the cars released. Cement shall be stored in a weather tight structure with the floor raised not less than one foot from the ground. If in bags it shall be piled in such a manner as to permit easy access for proper inspection and identification of each shipment. If in bulk it shall be stored in weather tight bins and for the proportioning of batches it shall be weighed

rather than measured by volume. All cement shall be subject at any time to retest. If under retest it fails to meet any of the requirements of the specifications it will be rejected and shall be promptly removed from the site of the work by the contractor.

Where the Railroad Company furnishes the cement and the injury is due to negligence on the part of the contractor to properly care for it, the cost of such cement shall be charged to the contractor. The contractor shall clean, bundle and load for shipment all empty cloth cement bags and the cost of this shall be included in the price per cubic yard for concrete. The contractor shall reimburse the Railroad Company for all cloth bags which he fails to prepare for shipment.

232. Aggregates

Fine and coarse aggregates shall be stored separately and in such manner as to avoid the inclusion of dirt and other foreign material in the concrete. Aggregates shall be unloaded and piled in such manner as to maintain the uniform grading of the sizes. Stock piles of coarse aggregates shall be built in horizontal layers to avoid segregation.

233. Steel Reinforcement

Steel reinforcement shall be stored in racks in such a manner as to avoid contact with the ground. If steel is to remain in storage on the ground for more than one month it shall be covered to protect it from weather. If steel accumulates rust and scale during storage it shall be cleaned before being used. Severe deterioration of this kind may be a basis for rejection.

Forms

234. General

Forms shall conform to the shape, lines and dimensions of the concrete as called for on the plans. Forms shall be of wood, steel or other approved material. They shall be of a type, size, shape, quality and strength that will produce true, smooth surfaces in accordance with the plans. Lumber in forms for exposed surfaces shall be dressed to uniform thickness. Undressed lumber may be used in forms for unexposed surfaces. Forms may be omitted for foundation concrete if in the opinion of the Engineer the sides of the excavation are sufficiently firm so that the concrete may be thoroughly rammed without causing the adjacent earth to yield; in which case the actual dimensions of the excavation shall be slightly greater than the plan dimensions of the foundations so as to insure design requirements.

235. Construction

Forms shall be constructed so as to be mortar tight and shall be made sufficiently rigid by the use of ties and bracing so as to prevent displacement or sagging between supports and to withstand the pressure, ramming, and vibration without deflection from the prescribed lines during and after placing of the concrete.

Joints in forms shall be horizontal or vertical and suitable devices shall be used to hold adjacent edges together in accurate alinement.

All forms shall be so constructed that they can be removed without hammering or prying against the concrete.

Bolts and rods shall preferably be used for internal ties; they shall be so arranged that when the forms are removed no metal shall be within one inch of any surface.

Any material once used in forms shall be thoroughly cleaned before being used again, and forms which have been used repeatedly and are not acceptable to the Engineer for further use shall be discarded or satisfactorily repaired.

In the case of very long spans where no intermediate supports are possible, the probable deflection in the forms due to the weight of the fresh concrete shall be compensated for so that the finished members shall conform accurately to the desired line and grade. If adequate foundation for shores cannot be secured, truss supports shall be provided.

Shores supporting successive stories shall be placed directly over those below, or so designed and placed that the load will be transmitted directly to them.

236. Moldings

Unless otherwise specified or directed by the Engineer, suitable moldings or bevels shall be placed in the angles of forms to round or bevel the edges of the concrete including abutting edges of expansion joints.

237. Oiling

The inside of forms shall be coated with non-staining mineral oil or other approved material which shall be applied before the reinforcement is placed.

238. Temporary Openings

Temporary openings shall be provided at the base of column and wall forms, and at other points where necessary to facilitate cleaning and inspection immediately before depositing concrete. Forms for walls or other thin sections of considerable height shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will avoid accumulation of hardened concrete on the forms or metal reinforcement.

239. Removal

The removal of forms shall not be started until the concrete has attained the necessary strength to support its own weight and any construction live loads. Forms shall be removed in such manner as not to injure the concrete.

Metal Reinforcement

240. Cleaning

Metal reinforcement, before being positioned, shall be thoroughly cleaned of mill and rust scale, dirt, grease or coating that will tend to destroy or reduce the bond, and after being placed, shall be maintained in a clean condition until completely embedded in concrete. Reinforcement appreciably reduced in section shall be rejected.

241. Bending

Reinforcement shall be accurately formed to the dimensions indicated on the plans. Stirrups and tie bars shall be bent around a pin having a diameter not less than two times the minimum thickness of the bar. Bends for other bars shall be made around a pin having a diameter not less than six times the minimum thickness except for bars larger than one inch, in which case the bends shall be made around a pin of eight bar diameter. All bars shall be bent cold.

242. Straightening

Metal reinforcement shall not be bent or straightened in a manner that will injure the material. Bars with kinks or bends not shown on plan shall be rejected. Heating of reinforcement will be permitted only when the entire operation is approved by the Engineer.

243. Placing

Metal reinforcement shall be accurately positioned and secured against displacement by using annealed iron wire ties or suitable clips, or spot welding at intersections, and shall be supported by concrete or metal supports, spacers or metal hangers. Metal clips or supports shall not be placed in contact with forms for exposed surfaces. Where reinforcing is supported by concrete blocks they shall be of a quality equal to the concrete into which they are to be incorporated and shall be tapered to insure unyielding incorporation in the finished structure.

The minimum center-to-center distance between parallel bars shall be 2½ times the diameter of round or 3 times the side dimensions for square bars, but in no case shall the clear spacing between the bars be less than twice the maximum size of the coarse aggregate, nor shall the clear depth from the face of the finished surface be less than one inch.

244. Moisture Protection

At those surfaces of footings and other principal structural members in which the concrete is deposited directly against the ground, metal reinforcement shall have a minimum covering of 3 inches of concrete. At other surfaces of concrete exposed to the ground or to severe weathering conditions, metal reinforcement shall be protected by not less than 2 inches of concrete for bars over ⅝ inch in diameter, and 1½ inches for bars ⅝ inch in diameter or less.

In concrete exposed to sea water the metal reinforcement shall be placed not less than 3 inches from any plane or curved surface, and at corners it shall be not less than 4 inches from adjacent surfaces.

245. Splicing

When it is necessary to splice reinforcement at points other than shown on the plans, the character of the splice shall be determined by the Engineer. Splices shall not be made at points of maximum stress and splices in adjacent bars shall be staggered.

246. Future Bonding

Exposed reinforcement intended for bonding with future extensions shall be protected from corrosion in an approved manner.

Joints

247. Location of Joints

Instructions given on the plans, in the detailed specifications, or schedule governing the work, shall be strictly followed. When the structures or portions of the structures are designed to be monolithic, they shall be cast integrally, except as hereinafter modified. When necessary to provide construction joints not indicated or specified, such joints shall be located as directed by the Engineer and formed so as to not impair the strength and to least impair the appearance of the structure.

Joints in columns shall be made at the underside of floor members and at floor levels. Haunches and column capitals shall be considered as part of and continuous with the floor or roof. At least two hours shall elapse after depositing concrete in columns or walls before depositing the concrete in the floor system.

248. Procedure in Forming Joints

The procedure specified in Section 224 for bonding new concrete to old shall be followed in the formation of all joints. The reinforcement shall continue through the joint. For concrete without reinforcement, shearing strength shall be provided by means of a concrete key or dowel bars as the Engineer may direct.

249. Extra Steel at Construction Joints

Where a construction joint is required in a section of a building more than 100 feet long or more than 100 feet between expansion joints, special reinforcement shall be placed at right angles to the joint and extending in both directions from the joint 40 diameters in the case of deformed bars and 50 diameters in the case of plain bars. This reinforcement shall be placed near the face of the member opposite from the main tensile reinforcement. The cross-sectional area of such reinforcement shall not be less than 0.5 percent of the section of the members cut by the joint.

250. Watertight Construction Joints

Vertical construction joints shall not be made in watertight construction unless shown on the plans or authorized by the Engineer.

Where a horizontal construction joint is required to resist water pressure, special care shall be taken in finishing the surface to which the succeeding concrete is to be bonded. The consistency of the concrete shall be carefully controlled so that it can be placed with a minimum of puddling with no free water showing. The surface shall be protected from loss of moisture and from mechanical injury. In applying the new concrete the procedure specified in Section 224 shall be followed.

Report on Assignment 12

Specifications for Test Borings

Collaborating with Committee 1—Roadway and Ballast

W. R. Wilson (chairman, subcommittee), G. H. Dayett, Theodore Doll, Reuben Hayes, W. A. Kingman, R. L. Mays, Roscoe Owen, O. V. Parsons, C. H. Splitstone, Jamison Vawter.

Last year the committee submitted as information, Specifications for Test Borings, together with a table of Methods of Underground Exploration and Sampling, and a sample page of Test Boring Data. The committee now recommends that the table appearing on page 323, the sample page on page 327 and the specifications for test borings on pages 328 to 332 of Volume 42, Proceedings for 1941, be adopted for publication in the Manual.

Report of Special Committee on Waterproofing of Railway Structures

J. A. Lahmer, *Chairman,*
F. E. Bates
G. E. Boyd
C. H. Chapin
A. C. Copland
J. P. Gallagher
A. C. Irwin
L. H. Laffoley
F. J. Pitcher
G. E. Robinson
F. P. Turner
L. W. Walter
H. T. Welty
C. A. Whipple
O. G. Wilbur
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

Progress report, including recommended revisions of the Specifications for Membrane Waterproofing, presented below.

2. Waterproofing of railway structures.

Progress report on comparative tests, presented as information ..... page 358
Progress report on other subjects under study, presented as information .. page 359

The Special Committee on Waterproofing of Railway Structures,

J. A. Lahmer, *Chairman.*

Report on Assignment 1

Revision of Manual

J. A. Lahmer (chairman, subcommittee), F. E. Bates, G. E. Boyd, C. H. Chapin, A. C. Copland, J. P. Gallagher, A. C. Irwin, L. H. Laffoley, F. J. Pitcher, G. E. Robinson, F. P. Turner, L. W. Walter, H. T. Welty, C. A. Whipple, O. G. Wilbur.

Your committee offers the following revisions of the Specifications for Membrane Waterproofing for adoption.

Change the last sentence of paragraph 2 of Section 207, Fabric, to read:

This shall be accomplished by spraying the fabric with the saturant or by passing the fabric through the saturant, and then calendering it in the presence of heat.

Change the first two requirements in Section 208, Untreated Fabric, to read:

(a) Thread count in either direction: Minimum 26; maximum 32.
(b) Average weight per square yard: Not less than 4 ounces including not to exceed 6 percent moisture regain.

Change requirements (c), (f) and (g) in Section 209, Treated Fabric, to read:

(c) Average weight per square yard: Not less than 11 ounces.
(f) Elongation without fracture: When measured by rule or scale, not less than 10 percent; when measured by autographic recording device, not less than 8 percent.

Bulletin 429, January, 1942.

(g) Pliability at 32° F.: Shall not crack when bent over a $\frac{1}{16}$-inch mandrel through an arc of 180° in one direction and then through 360° over the same mandrel in the opposite direction.

The change in Section 207 consists of addition of "spraying the fabric with saturant." This recognizes a method which has produced treated fabric for a number of years equal to that produced by passing the fabric through the saturant.

Requirements for 5-ounce cloth having thread count of 18 to 24 have been eliminated from Section 208 and Section 209 because information has been received from producers that such cloth is no longer available except on special order and at extra cost. Change in Section 209 (f) recognizes improved machinery for measuring elongation. Change in Section 209 (g) simply explains the test and does not change its meaning.

Report on Assignment 2

Waterproofing of Railway Structures

(a) Comparative Tests of Waterproofing Asphalts and Coal Tar Pitches

G. E. Robinson (chairman, subcommittee), A. C. Irwin, H. T. Welty.

Your committee presents the following report as information.

The sum of $500 was allotted for the conduct of comparative tests on waterproofing bitumens. In recent years there have been developments in the refining processes for bitumens. The object of the proposed tests is to determine essential characteristics of bitumens available for waterproofing purposes as a guide in reviewing specification requirements.

A series of tests has been outlined which consists of the usual tests included for identification purposes and other tests designed to bring out the practical qualities of the materials under conditions as close to those encountered in service as could be devised.

Invitations were extended to 13 of the largest producers to furnish samples of their products for test and also to conduct parallel tests in their own laboratories. Samples were received from ten producers. The laboratories of three of these producers will collaborate in the test. Four of the samples were pitch, and the remainder were asphalt. In each case 15 1-gallon samples were obtained. The labels were removed and the samples identified as A, B, C, etc., and samples of each product sent to the collaborating laboratories for test.

Our tests are being made under the direction of Mr. G. M. Magee, research engineer of the Association of American Railroads, and Mr. R. E. Coughlan, engineer of tests, Chicago & North Western Railway, at the railway's laboratory in Chicago. Those tests which require no special equipment have been started and are expected to be complete early in 1942. The remainder of the tests will be completed later in the year.

Report on Assignment 2

Waterproofing of Railway Structures

(b) Other Subjects Under Study

Your committee offers the following brief comments on its study of ASTM revised specifications for waterproofing materials:

D 41–39 T Specifications for Primer for Use with Asphalt in Dampproofing and Waterproofing; D 43–37 T Specifications for Creosote for Priming Coat with Coal-Tar Pitch in Dampproofing and Waterproofing.—These are satisfactory to your committee, but further action will be deferred until after they are adopted as standard by ASTM.

D 173–40 T Specifications for Woven Cotton Fabrics Saturated with Bituminous Substances for use in Waterproofing.—Differences between AREA and ASTM requirements are being discussed with the ASTM committee.

D 449–37 T Specifications for Asphalt for Dampproofing and Waterproofing, D 450–38 T Specifications for Coal-Tar Pitch for Roofing, Dampproofing, and Waterproofing.—Further comment on these specifications will be deferred until after completion of the comparative tests being conducted by this committee.

Report of Special Committee on Impact

J. B. Hunley, *Chairman,*
O. F. Dalstrom
S. F. Grear
A. R. Harris
Meyer Hirschthal
C. S. Johnson
A. N. Laird
B. R. Leffler
C. T. G. Looney
G. E. Robinson
C. H. Sandberg
C. P. Schantz
C. E. Sloan
F. E. Turneaure
A. R. Wilson
W. M. Wilson
Committee

To the American Railway Engineering Association:

Your committee submits herewith its report on the following subjects:

1. Tests of short steel spans with open floor, together with effect of track inequalities and worn wheels on such spans.

   Progress report, submitted as information ..... page 361

2. Tests of steel spans with ballasted deck, including spans with precast concrete decks and poured-in-place concrete decks; also tests on ballasted decks with timber floors; particular attention to be given to the damping due to the type of deck and the track ballast.

   Progress report, submitted as information ..... page 361

3. Tests of dynamic shear in steel girder and truss spans.

   Progress report, submitted as information ..... page 361

4. Tests of impact in columns and hangers of steel spans.

   No report.

5. Tests of rigid frame structures of steel and concrete.

   No report.

6. Analysis of additional data from impact tests.

   Progress report, submitted as information ..... page 362

7. Determination of damping factors of steel spans and variation in amount of damping with change in loading, by means of tests with an oscillator and model tests.

   Progress report, submitted as information ..... page 362

The Special Committee on Impact,
J. B. Hunley, *Chairman.*

Bulletin 429, January, 1942.

Report on Assignment 1

Tests of Short Steel Spans with Open Floor, Together with Effect of Track Inequalities and Worn Wheels on Such Spans

During the past season tests have been made on one 20-ft. I-beam span and one 30-ft. deck girder with open decks. Tests were also made on one 22-ft. I-beam span and 23-ft. deck girder with ballasted decks.

In testing these spans, runs were first made with a battered joint, in one rail, at or near the center of the span. The rails were then replaced so that there would be no joints on the spans, and the runs repeated.

Both steam and Diesel locomotives were used in these tests, the attained speed of the latter type approaching 100 m.p.h. Stresses were measured at various points by means of magnetic strain gages recorded on an oscillograph.

The committee reports progress in collecting the necessary data, which, when analyzed, should make possible a final report on this assignment next year.

Report on Assignment 2

Tests of Steel Spans with Ballasted Decks

Including Spans with Precast Concrete Decks and Poured-In-Place Concrete Decks; Also Tests on Ballasted Decks with Timber Floors; Particular Attention To Be Given to the Damping, Due to the Type of Deck and the Track Ballast

The two short spans with ballasted decks, tested in connection with Assignment 1, had timber floors, and the data obtained will probably furnish sufficient information for short spans of this type. The committee has available for analysis, data obtained from previous tests, on an 81-ft. deck girder span, with a ballasted floor, carried by a concrete poured-in-place deck. (See Assignment 6). Other spans will be tested in 1942.

The committee reports progress in assembling data on the subject, and this report is submitted as information.

Report on Assignment 3

Tests of Dynamic Shear in Steel Girders and Truss Spans

The dynamic shear in web members and the end posts of a 102-ft. 6-in. riveted through truss span were measured in connection with the test made under Assignment 7. Other spans will be tested as opportunity arises, both under moving loads and with the oscillator.

The committee reports progress in assembling data on this subject, and this report is submitted as information.

Report on Assignment 6

Analysis of Additional Data from Impact Tests

The Pennsylvania Railroad has kindly furnished the committee with the complete data obtained from tests on an 81-ft. ballasted deck girder span, at Elkton, Md., this span having a poured-in-place concrete deck. Both steam and electric locomotives were used, and the speeds attained were very high. The stresses were measured with magnetic strain gages and recorded by means of oscillographs.

The analysis of these data is now under way and the results will be reported next year.

The committee reports, as information, progress on the analysis of these data.

Report on Assignment 7

Determination of Damping Factors of Steel Spans and Variation in Amount of Damping with Change in Loading, by Means of Tests with an Oscillator, and Model Tests

An oscillator was attached to a riveted through truss span 102 ft. 6 in. long, and the span was vibrated at various frequencies under various conditions of loading: (1) Unloaded, (2) loaded with a stationary cut of heavily loaded cars, and (3) loaded with a stationary heavy locomotive. By means of magnetic strain gages, stresses were measured in various members, and parts of members, and deflections at the center of the span were recorded by deflectometers.

A large amount of interesting data was obtained, which has not been completely analyzed. Before any definite information as to damping can be obtained, it will be necessary to test other spans; and it is the intention to install this oscillator on suitable spans, when such spans are being tested under moving load.

The committee reports, as information, progress of collecting data on this subject.

Report of Committee 15—Iron and Steel Structures

J. E. Bernhardt, *Chairman,*
F. E. Bates
R. N. Brodie
A. W. Carpenter
C. H. Chapin
O. F. Dalstrom
R. P. Davis
R. L. Eason
Herbert Ensz
W. G. Grove
O. E. Hager
G. A. Haggander
F. S. Hales
Shortridge Hardesty
O. E. Hovey*
J. B. Hunley
Jonathan Jones
A. R. Ketterson
A. M. Knowles
B. R. Leffler
H. S. Loeffler
F. M. Masters
C. H. Mercer
C. T. Morris
O. K. Peck
F. J. Pitcher
Albert Reichmann
O. E. Selby
T. C. Shedd
I. L. Simmons
G. L. Staley
C. E. Sloan, *Vice-Chairman,*
H. C. Tammen
G. H. Tinker
G. H. Trout
F. E. Turneaure
F. P. Turner
R. A. Van Ness
T. M. von Sprecken
C. E. Webb
Einar Weidemann**
H. T. Welty
C. D. Williams
A. R. Wilson
W. M. Wilson
H. A. Wistrich
Committee.

* Died April 15, 1941; ** Died November 12, 1941.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Revisions of specifications for steel railway bridges and of other parts of Chapter 15 of the Manual, submitted for adoption and publication in the Manual .... page 365

   Revised specifications for steel railway turntables, submitted as information page 368

2. Specifications for fusion welding and gas cutting for steel structures, collaborating with ASTM Committee A–1 on Steel, and the American Welding Society Conference Committee on Bridges.

   No report.

3. Design of expansion joints involving iron and steel structures.

   No report.

4. Relation between fatigue of metals and bridge design.

   No report. A paper on this subject, by Prof. W. M. Wilson, appears in AREA Bulletin 426, page 1, also in Monograph Section, Vol. 43, Proceedings, 1942.

5. Review specifications for highway bridges of the American Association of State Highway Officials insofar as they relate to steel construction, conferring with that association.

   Final report, presented as information as a part of the report on Assignment 1—Revision of Manual ..... page 367

6. Progress in design of bridge details.

No report.

7. Rigid-frame design.

Progress report, presented as information ..... page 374

The Committee on Iron and Steel Structures,
J. E. Bernhardt, *Chairman.*

Otis E. Hovey—Einar Weidemann

The committee records with deep sorrow the death during the current year of two of its members.

Otis E. Hovey

Mr. Hovey was born April 9, 1864, and died on April 15, 1941.

Mr. Hovey had a distinguished career in engineering from his graduation from Dartmouth College in 1885. His early work included a short period of railroading, after which he devoted himself to design in structural steel. During the greater part of his professional life he was identified with structural steel fabrication, first with the Union Bridge Company and later with the American Bridge Company, becoming assistant chief engineer of the latter company in 1907 and continuing in that capacity until shortly before his retirement in 1934.

Mr. Hovey maintained an active interest in the field of education throughout most of his professional career, particularly in the Thayer School of Engineering at Dartmouth College. He was also a lecturer at Yale and Princeton universities. He became a member of the American Railway Engineering Association in 1923, being appointed a member of Committee 15 a year later; and from that time until his death, he took an active part in the work of the committee, contributing ably on subjects requiring extensive study and keen analysis.

Einar Weidemann

Mr. Weidemann was born at Trondhjem, Norway, on May 29, 1877, and died on November 12, 1941.

Following his education at the Technical Institute of Trondhjem, from which he was graduated with the degree of civil engineering in 1897, and several years' service with the Norwegian government on railroad construction, he came to the United States in 1903. After being employed for a time as a structural draftsman for the American Bridge Company and in the office of a consulting engineer, he was appointed engineer of structural design on the Pennsylvania in 1909, and continued in the employ of that railroad from that date until the time of his death, with the exception of the period from 1915 to 1926, during which time he was in charge of structural design for the Chicago Union Station Company. For a number of years prior to his death he was engineer of bridges and buildings, Western Region.

Mr. Weidemann became a member of the Association in 1928 and had been a member of the Committee on Iron and Steel Structures since 1939.

Report on Assignment 1

Revision of Manual

O. E. Selby (chairman, subcommittee), R. N. Brodie, O. F. Dalstrom, Herbert Ensz, Shortridge Hardesty, O. K. Peck, G. H. Trout, F. E. Turneaure, C. E. Webb, H. T. Welty.

Your committee presents herewith a tabulation of revisions of the Specifications for Steel Railway Bridges, which are purely of an editorial nature and are, therefore, offered as information, except the following three articles which are submitted for formal adoption:

Article 432, p. 15–16
Article 433, p. 15–17
Article 545, p. 15–24

Specifications for Steel Railway Bridges

Item 6 p. 15–2
Revise to read "Shop painting."

1 p. 15–3
Print "Railway Company" in first line without capital letters.

103 p. 15–4
Revise second paragraph to read: "The girders of deck girder spans and the stringers of deck and through spans" etc.

105 p. 15–4
Make the last sentence of second paragraph a separate paragraph following first paragraph.

106 p. 15–5
Revise the last two sentences to read:
"For pin-connected trusses, the distance between center lines of chord pins."
"For riveted trusses, the distance between gravity axes of chords."

202 p. 15–5
In last line change "lineal" to "linear."

203 p. 15–5
Revise first paragraph to read:
"The recommended live load for each track is the Cooper E–72 load, shown in Fig. 1502, or that shown in Fig. 1503. The load that gives the larger stress shall be used."
(Redraw the diagrams, Figs. 1502 and 1503 to make them more distinct and to conform to AREA rules.)

208 p. 15–7
Revise the formula for "E" to read: $E = \frac{S^2D}{1500} - 3 = \frac{C - 5.265}{1.755}$

211, 212 p. 15–8
Omit last paragraph of Art. 211, which lists three articles. Then interchange and renumber Articles 211 and 212.

301 (a) p. 15–10

In last line change "lesser" to "less."

404 p. 15–11

Revise the article to read: "Connections of members shall be so arranged, if practicable, that their gravity axes will intersect in a point. If eccentric connections are unavoidable, the members shall be proportioned for the combined stresses."

415 p. 15–13

Revise the last paragraph to read: "The distance from the center of a rivet in the outer gage line to the edge of an outside plate shall not exceed 8 times the thickness of the plate."

420 p. 15–14

Change "stress" to "force" in first line of second paragraph and in definition of "V".

432 p. 15–16

Revise to read "Stiffeners shall be placed at end bearings and at points of bearing of concentrated loads for plate girders and beams. They shall extend as nearly as practicable to the edges of the flange to give effective distribution and shall be connected to the web by enough rivets to transmit the stress. Such stiffeners shall not be crimped. Only that part of the stiffener cross section that lies outside the fillet of the flange shall be considered effective in bearing."

433 p. 15–17

Revise the formula to read: $d = \frac{10{,}500t}{\sqrt{S}}$ and omit definition of "a."

517 p. 15–21

Revise first sentence to read: "Rivets shall be heated uniformly to a light cherry red and driven while hot to fill the holes completely." Omit third sentence.

519 p. 15–21

Change "when" to "if."

520 p. 15–21

Insert comma after "required."

523a, 523b p. 15–22

Change the numbers of these two articles to 524 and 525 respectively, and renumber the subsequent articles in sequence to Article 533.

545 p. 15–24

Insert after "tallow" in second line: "or other protective compound approved by the Engineer."

603 p. 15–25

Insert "made" before "available" in last line of second paragraph.

701 p. 15–25

Add the following sentence to the first paragraph: "The weight of shop paint shall not be included."

1301 p. 15–44

Change the reference to: "—the current Specifications of the American Society for Testing Materials, Serial A 48, Class 25."

1401 p. 15–44

Change the reference to: "—the current Specifications of the American Society for Testing Materials, Serial A 47."

1501 p. 15–44

Change the reference to: "—the current Specifications of the American Society for Testing Materials, Serial A 42."

1502 p. 15–44

Change the reference to: "—the current Specifications of the American Society for Testing Materials, Serial A 207."

1604 p. 15–47

Change "stress" to "force" in first line of first paragraph and in definition of "V."

1701 p. 15–48

Change the reference to: "—the current Specifications of the American Society for Testing Materials, Serial B 22."

1702 p. 15–48

Change the reference to: "—the current Specifications of the American Society for Testing Materials, Serial B 100."

Appendix A—Formulas for Compression Members pp. 15–48.1 and 15–48.2

Strike out all following the line, "f = factor of safety based on yield point," and substitute:

"The coefficient 0.25 in the denominators of the formulas provides for inherent crookedness and unknown eccentricity.

"The factors of safety to be used in the formulas are computed as follows:

"From the parabolic formulas in Articles 301 and 1601, for $\frac{l}{r} = 0$

$$\begin{aligned} p &= 15{,}000 \text{ for structural steel} \\ &= 20{,}000 \text{ for silicon steel} \\ &= 24{,}000 \text{ for nickel steel} \end{aligned}$$

"From formulas (1) and (2), for $\frac{l}{r} = 0$

$$p = \frac{y}{f} \div 1.25 \text{ from which } f = \frac{y}{1.25p}$$

"Using the foregoing values of y and p, the following values of f are derived:

$$\begin{aligned} f &= 1.76 \text{ for structural steel} \\ &= 1.80 \text{ for silicon steel} \\ &= 1.83\tfrac{1}{3} \text{ for nickel steel} \end{aligned}$$

Your committee also offers the following tentative revisions of other parts of Chapter 15—Iron and Steel Structures, with the recommendation that they be approved.

Specifications for Steel Highway Bridges p. 15–94

The committee recommends that the reference to Specifications for Steel Highway Bridges be withdrawn from the Manual and that the assignment be discontinued.

Principles for Detailed Design of Flashing, Drainage, Reinforcement and Protection for Waterproofing Purposes

502 p. 15–103

To the list of enumerated materials add

(e) Pre-molded asphalt.

Fusion Welding

p. 15–133

Revise to read: "When welding is permitted, it is recommended that the Specifications adopted under the title above by the American Welding Society in 1936 be used pending further consideration of the subject."

Report on Assignment 2

Revision of Manual

Revision of Specifications for Steel Railway Turntables

A. M. Knowles (chairman, subcommittee), F. E. Bates, C. H. Chapin, F. S. Hales, O. E. Hovey, H. S. Loeffler, C. H. Mercer, O. K. Peck, O. E. Selby, C. E. Sloan, G. L. Staley, G. H. Trout, F. P. Turner, T. M. von Sprecken, C. E. Webb, C. D. Williams.

Your committee offers the following revised Specifications for Steel Railway Turntables as information with the object of presenting them later for adoption and publication in the Manual to replace the specifications that now appear on pages 15–109 to 15–114, inclusive.

SPECIFICATIONS FOR STEEL RAILWAY TURNTABLES

Section CONTENTS *Page*

Information to be Given Bidders .....
Specifications Which Apply .....
I General Features of Design .....
II Loads .....
III Unit Stresses and Proportioning of Parts .....
IV Details of Design .....
V Center .....
VI End Trucks .....
VII Pit and Tracks .....

INFORMATION TO BE GIVEN BIDDERS *Article*

1. What is the live load?
2. Will there be separate contracts for the different parts of the table?
3. Normal time for turning the table.
4. House for operator shall be built by whom?
5. Will the Company furnish the deck and track material?
6. Type of center 501
7. Kind of power 104

Article

8. Kind of fuel for internal combustion engine 104
9. Electric power service characteristics 104
10. At what point will the Railway Company deliver power?
11. What are the conditions at the site?

    Furnish plan showing the general dimensions necessary for designing the table:

    Length of table.
    Type of table.
    Type of floor.
    General dimensions of pit.

12. Shop painting.
13. Will the Company erect the table?
14. Will the Company furnish and apply the field paint?
15. What kind of field paint will be approved?

1. Specifications

The current Specifications for Steel Railway Bridges and the current Specifications for Movable Railway Bridges, American Railway Engineering Association, shall apply except as otherwise specified herein.

Special materials that are not covered by the specifications named above shall be in accordance with the current specifications of the American Society for Testing Materials. Structural and rivet steel preferably shall be copper-bearing.

I. GENERAL FEATURES OF DESIGN

101. Types of Turntables

These specifications cover the following types of turntables:

(a) Balanced.
(b) Three-point-support.
    (1) Continuous.
    (2) Non-continuous.

Tables preferably shall be of deck construction, but may be made with through girders, pony trusses, or through trusses.

102. Length

The nominal length of the table is the over-all length of the girders. The length preferably shall be a multiple of 5 feet.

The length shall be:

(a) For balanced tables, such that no part of the longest locomotive to be turned will project beyond the face of the pit wall when the locomotive, with tender empty, is balanced on the table.
(b) For three-point-support tables, such that no part of the longest locomotive to be turned will project beyond the face of the pit wall.

103. Clearances

The clearances shall be not less than those shown in Fig. 1522. The depth from top of rail to top of tie shall be taken as 8 inches.

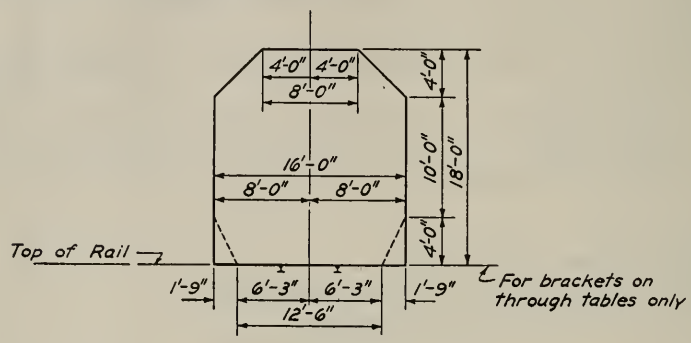


FIG. 1522.

104. Power Operation

Tables shall be power operated unless otherwise specified. The power equipment shall be of the kind specified by the Engineer and shall conform with the applicable requirements of the current AREA Specifications for Movable Railway Bridges.

For the calculation of power requirements and the forces required for turning, the position of the live load on three-point-support tables shall be taken with the locomotive in the most unfavorable position.

The maximum speed at the circle rail shall be 200 feet per minute.

II. LOADS

201. Loads

The table shall be proportioned for the following loads and forces:

(a) Dead load.
(b) Live load.
(c) Force required to rotate the table.

The stresses from these loads and forces shall be shown separately on the stress sheets.

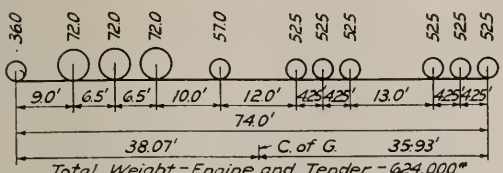
202. Live Loads for Design

The recommended live load is that shown in Fig. 1523 for the corresponding length of table.

The Engineer shall specify the live load to be used, such load to be proportional to the recommended load, with the same axle spacing.

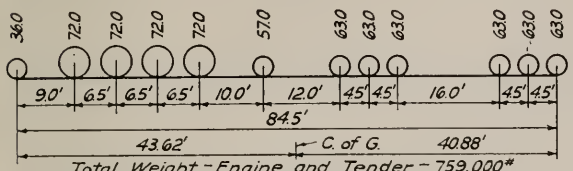
The ends of the table, including main girders, end floor beams, trucks, and other parts above the foundation similarly affected, shall be proportioned for an axle load of 75,000 pounds (in addition to the specified live load) in the most effective position.

The center pivot shall be proportioned for the specified live load plus 25 percent. The center cross girder assembly with its connections to the main girder shall be proportioned for the specified live load plus 75 percent.

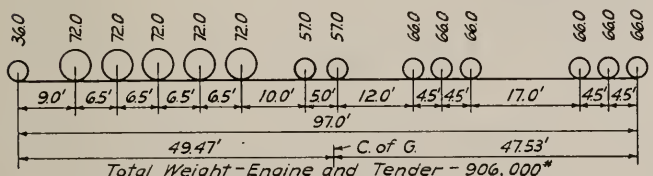


80 FT. TABLE

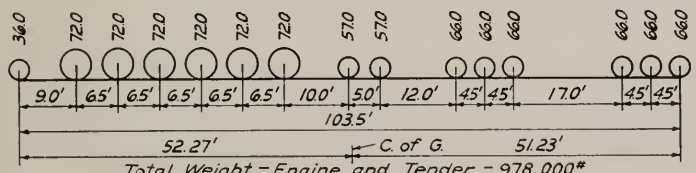
NOTE:
Center of Gravity computed with tender full.



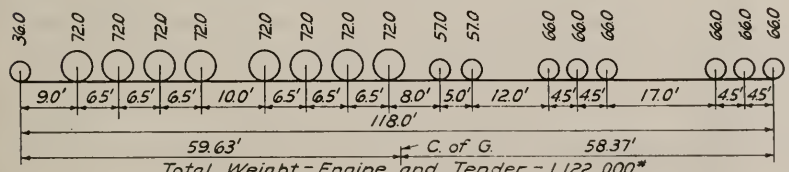
90 FT. TABLE



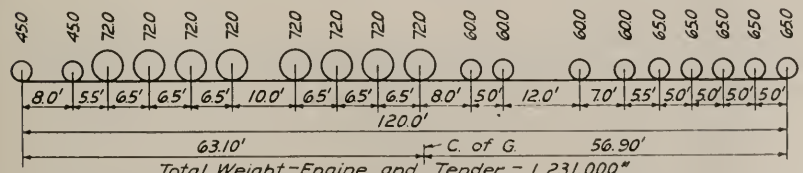
100 FT. TABLE



100 AND 115 FT. TABLE



120 FT. TABLE



125 FT. TABLE AND OVER

FIG. 1523.

A

III. UNIT STRESSES AND PROPORTIONING OF PARTS

301. Unit Stresses

The unit stresses shall be as given in the specifications named in Section 1 except for parts that determine the deflection of balanced tables. Such parts shall be so proportioned that the live load deflection at the ends will not exceed ½ inch for an 80 foot table; and for longer tables, ⅛ inch more for each 10 feet of length in excess of 80 feet.

Three-point-support tables shall be designed for a variation of one inch either way in the relative elevations of the circle-rail and the center support.

In three-point-support tables of the continuous type, vertical stiffness is not essential; rather a degree of flexibility is desirable. Such tables shall be proportioned to provide positive reactions at all three supports and to avoid uplift regardless of the position of the live load.

In three-point-support tables of the non-continuous type there shall be flexible connections at the center support to allow for the girder deflection, and for the variation in the circle-rail elevation specified above.

IV. DETAILS OF DESIGN

401. Bracing

Horizontal bracing shall be provided to allow for turning the table by means of power applied at either end. There shall be both top and bottom lateral bracing systems where practicable. Balanced tables shall be braced to prevent warp.

The thickness of bracing material shall be not less than ½ inch.

402. Inspection

Tables shall be so designed as to facilitate inspection and making repairs.

403. Protection of Parts

The center, center cross girders, and machinery shall be protected, preferably by metal housing, against the entry of water, cinders, and dirt.

The thickness of any full-length top cover plates of deck girders, stringers, floor beams, and center cross girders shall be increased ⅛ inch over the computed thickness. The section of other parts subject to excessive corrosion shall be increased over the computed section.

404. Foot Walk

There shall be footwalks along both sides of the track. On deck tables they shall be protected by railings.

405. Collector Ring Support

If the feed wires of an electrically operated table are over the pit, there shall be a structural steel frame attached to the main girders to support the wires and collector ring over the center.

V. CENTER

501. Type of Pivot

The center pivot shall be of the flat-disc type unless the roller type is specified by the Engineer.

502. General Features

The point of application of the load shall be, as nearly as practicable, in a vertical through the center. The rotating portion of the center pivot shall be equipped with a saddle or pin to allow longitudinal rocking of the main girders.

The entire center unit shall be as nearly dustproof and waterproof as practicable. It shall be equipped with substantial and effective lubricating devices and shall be so designed that it may readily be removed, taken apart, inspected, cleaned, repaired, lubricated, and replaced. There shall be means of adjustment for height.

503. Materials

A disc pivot shall comprise either one disc of phosphor bronze or two discs, one of phosphor bronze and one of hardened steel, encased in an oil-tight recess in a rolled or cast steel pedestal. For two-disc installations the discs shall be so secured that sliding will take place only at the surfaces of contact of the discs.

A roller pivot shall consist of a nest of forged steel, tempered, conical rollers equipped with bronze thrust bearings, turning between top and bottom treads of heat-treated rolled or cast steel. The rollers shall be held in a frame of rolled or cast steel inner and outer rings secured to the rollers by high-tension, heat-treated bolts. The pivot shall be encased in an oil-tight recess in a cast steel casing.

Sliding and rolling surfaces shall be finished and polished accurately.

VI. END TRUCKS

601. General Features

The end trucks shall be of substantial construction and shall be braced to hold the axles of the wheels in lines radiating from the center of rotation. The braces shall be non-adjustable in length.

There shall be either two or four wheels at each end of the table. If there are only two, they shall be placed outside the main girders and mounted in a single truck frame connected rigidly to the main girders. If there are four wheels, they shall be mounted in pairs in separate trucks so attached to the main girders that the loads transmitted to the wheels will be equalized.

602. Wheels and Axles

Wheels shall be AAR Multiple-Wear wrought steel wheels of as large diameter as practicable except that the rims shall be cylindrical and not flanged and the webs preferably shall be straight. The wheels shall be bored for tight fit and mounted on steel axles by heavy pressure. In addition, wheels used as drivers shall be keyed to the axles.

Wheel material shall be ASTM A 57. Wheel treads shall be toughened to a hardness of not less than Brinell 330. Axle material shall be ASTM A 236, Class G.

603. Bearing Boxes

The bearing boxes shall be of cast or rolled steel with removable phosphor bronze bushings or bearings of other type acceptable to the Engineer.

Bearing boxes shall be compact, with lids that can be opened readily, and of such construction as will provide for effective lubrication and prevent the entrance of water and dirt.

Bearing boxes of three-point-bearing tables shall be equipped with roller bearings if required by the Engineer.

VII. PIT AND TRACKS

701. Circle-Rail

The circle-rail shall be of a section not less than the heaviest standard rail used by the railway company and preferably not less than 131 pounds per yard.

There shall be provision for adjustment of the elevation and the radius of the circle-rail, and for drainage under it.

The top of the circle-rail shall be in a horizontal plane.

The circle-rail shall be supported on steel beams embedded in the concrete foundation or on bearing plates set directly on the concrete foundation and anchored to it.

702. Radial Tracks

The ends of the rails in the radial tracks shall be held securely in line and elevation. The top of rail of all radial tracks shall be at the same elevation as the top of rail on the end of the table with the end wheels bearing.

Radial track rails ending at the circle-wall shall be full-length and anchored securely against longitudinal movement.

There shall be a clearance of ¾ inch between the ends of the radial track rails and the rails on the table.

A track layout with tangents extending from the face of the pit wall a distance at least equal to the locomotive wheel base is desirable. Anything less will result in side kick at the end of the table.

703. Rails on the Table

The rails on the table shall be held in line and elevation and anchored to prevent longitudinal movement. There shall be steel tie plates throughout.

The rails at the ends of the table shall be full length.

704. Pit

There shall be a clearance of 4 inches between the circle-wall and the ends of the table.

An inspection pit shall be provided in the circle-wall.

Report on Assignment 7

Rigid-Frame Design

T. C. Shedd (chairman, subcommittee), R. N. Brodie, R. L. Eason, Herbert Ensz, W. G. Grove, Shortridge Hardesty, Jonathan Jones, A. R. Ketterson, B. R. Leffler, C. T. Morris, F. J. Pitcher, F. E. Turneaure, C. E. Webb, H. T. Welty, C. D. Williams.

The following specifications are submitted as information with a view to presenting them later for adoption and publication in the Manual:

SPECIFICATIONS FOR THE DESIGN OF RIGID-FRAME STEEL BRIDGES

1. General Specifications

The current Specifications for Steel Railway Bridges of the American Railway Engineering Association shall apply to rigid-frame steel bridges, except as provided otherwise herein. References to article numbers are to those specifications.

2. Definition

The term "rigid-frame" is used here to mean a load-carrying frame in which the horizontal member is structurally integral with the upright supports; either or both may vary in section.*

3. Articulation at Footings

Hinged bearings for the upright supports are preferred. Where hinged bearings are not practicable, or, if provided, where the details of footings and cut-off walls may render them inoperative, the analysis of the rigid frames shall be made assuming:

(a) Fixed bases.
(b) Hinged bases.

and the design based on the larger stresses so determined.

4. Foundations

Footings shall be founded on rock, on substantially unyielding material, or on unyielding pile foundations.

If the footings are founded on piles, there shall be a sufficient number of battered piles to provide the necessary resistance to the horizontal thrust.

If conditions make it impracticable to provide resistance to the horizontal thrust by means of direct bearing or battered piles, steel tie rods may be used. Such tie rods shall be encased in concrete with a minimum cover of six inches.

5. Spacing

The distances between longitudinal frames shall be large enough to facilitate the attachment of bracing between them and for painting, but the distance between the exterior frames shall be not less than 1/15 of the span, and not less than six feet six inches.

6. Deflections

The proportions of frames preferably shall be such that the mid-span deflection of the frame will not exceed the deflection of a simple girder of the same span having a depth of $\frac{1}{12}$ of the span.

7. Distribution of Live Load

The lateral distribution of live load shall be in accordance with Article 205.

8. Impact

The impact shall be in accordance with Article 206. In the impact formula, "*L*" is the length, in feet, center to center of supports.

9. Loads and Forces

In addition to the loads and forces specified in Article 201, the frames shall be designed to resist the stresses resulting from earth pressure, temperature change, rib-shortening, and elastic yielding of supports.

The earth pressure against the cut-off walls is given by the formulas:[1]

$$P = \frac{1}{2}\, wh\ (h + 2h_1)\, \frac{1 - \sin\phi}{1 + \sin\phi} \qquad (44)$$

* The computation of shears, bending moments, and reactions should be made by recognized methods of analysis based on the line diagram formed by the centroidal axes of the members and on the gross moments of inertia of the members.

[1] From the AREA Manual, page 8–57.

The resultant pressure is horizontal and is applied at a distance from the base of the wall equal to

$$y = \frac{h^2 + 3hh_1}{3(h + 2h_1)} \quad \text{(45)}$$

P = the resultant pressure per foot of length of wall
w = the weight of the filling per cubic foot
h = the vertical height of the wall in feet
h_1 = the equivalent height of the surcharge = the weight of the surcharge in pounds per square foot divided by the weight of the filling in pounds per cubic foot
ϕ = the angle of repose of the filling
y = the distance from the base of the wall to the line of action of the resultant pressure

10. Combined Stresses

The frames shall be so proportioned that the combined axial and bending stresses, when adjusted to take account of conditions of lateral support, will not exceed the permissible stress for the material used.

This requirement will be met if the quantity

$\frac{f_a}{F_a} + \frac{f_b}{F_b}$ does not exceed 1.0

F_a = axial unit stress that would be permitted by these specifications if axial stress only existed
F_b = bending unit stress that would be permitted by these specifications if bending stress only existed
f_a = actual axial unit stress = axial stress divided by sectional area of member
f_b = actual bending unit stress = bending moment divided by section modulus of member

11. Unit Stresses

The stresses resulting from the combination of the earth pressure with the loads and forces of Article 201 shall be the designing stress.

In the application of Article 217, the earth pressure shall be included with the dead load, live load, impact, and centrifugal force.

12. Bracing

There shall be bracing in the planes of the compression flanges of both horizontal and upright members. If the top flanges are rigidly connected to a steel plate deck, or laterally restrained by a cast-in-place reinforced concrete deck, only such top lateral bracing as is required for erection purposes need be provided.

There shall be cross frames or diaphragms in all spaces between rigid frames, so placed as to act with the lateral bracing in providing positive lateral support for the flanges subjected to compressive stress. Such cross frames or diaphragms and their connections shall be adequate to resist the stresses induced by the distribution of the live load.

13. Stiffeners at Points of Bearing

(a) If the bottom flange of the horizontal member in a rigid frame is carried across the upright members and rested thereon, there shall be bearing stiffeners directly above the flanges of the upright members, milled to fit tight against the bottom flange of the horizontal member and designed to transmit the stress in the flanges of the upright members to the web of the horizontal member.

(b) If the inner flanges of the upright members are made continuous up to the top flange of the horizontal member, the ends of the bottom flange of the horizontal member shall be milled to bear against the inner flanges of the upright members. There shall be bearing stiffeners on the webs of the upright members opposite the milled ends of the bottom flange of the horizontal member designed to transmit the stress from that flange to the webs of the upright members.

(c) Rounded corners at the junction of horizontal and upright members are not considered stress-carrying elements.

14. Connections

Splices in the rigid frame shall be designed to develop the full value of the member.

Report of Committee 11—Records and Accounts

C. A. Knowles, *Chairman,*
Anton Anderson
F. B. Baldwin
H. D. Barnes
S. H. Barnhart
B. A. Bertenshaw
W. C. Bolin
E. V. Braden
W. F. Cummings
V. H. Doyle
D. E. Field
C. C. Haire
H. N. Halper
J. H. Hande
A. T. Hopkins
C. D. Johnson
W. R. Kettenring
E. M. Killough
P. R. Leete
W. M. Ludolph
D. O. Lyle
W. S. MacCulloch
W. S. McFetridge
O. M. Miles
H. L. Restall, *Vice-Chairman,*
A. T. Powell
C. P. Richardson
J. H. Roach
F. M. Spiegel
H. J. Stroebel
D. C. Teal
V. P. Turnburke
H. C. Wertenberger
Louis Wolf
A. O. Wolff
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

Progress report—presented as information ..... page 381

2. Bibliography on subjects pertaining to records and accounts.

Progress report—presented as information ..... page 381

3. Office and drafting room practices:

(a) Drafting equipment and tools;
(b) Specifications of materials to be used for drawings and draftings;
(c) Standard system for filing drawings.

Progress report—presented as information with recommended conclusions for publication in the Manual ..... page 383

4. Recommended practice to be followed with respect to maintenance of way accounts and statistical requirements, collaborating with interested committees.

Progress report—presented as information ..... page 387

5. Construction reports and records:

Forms for recording complete descriptive statement of quantities and other physical characteristics of construction projects.

No report.

6. Valuation

(a) Résumé of developments of the current year in connection with regulatory bodies and the courts.

Progress report—presented as information ..... page 389

(b) ICC valuation orders, reports and records.

Progress report—presented as information ..... page 392

7. Report upon changes in, revisions and interpretations of ICC accounting classifications.
   Progress report—presented as information ..... page 393

8. Methods for avoiding duplication of reports and for simplifying and coordinating work under the requirements of the ICC and other public authorities.
   No report.

9. Records of property leased and available for lease.
   No report.

THE COMMITTEE ON RECORDS AND ACCOUNTS,
C. A. KNOWLES, *Chairman.*

Henry Lehn

Henry Lehn, a member of the American Railway Engineering Association since 1906 and of the Committee on Records and Accounts since 1907, died September 14, 1940.

Mr. Lehn was born on October 14, 1871, and entered the service of the New York Central on June 4, 1894, in the office of the general roadmaster. He was transferred to the office of the engineer maintenance of way in August 1898, and to the chief engineer's office in May 1899. In April 1904 he was appointed maintenance of way accountant in the Accounting department, and served in various capacities as valuation accountant, disbursement accountant, etc., until April 1, 1933, when his title was changed to that of traveling accountant, reporting to the departmental accountant at Utica. He retired from service as of March 31, 1939.

Commitee 11 has lost by his death its oldest member, and the American Railway Engineering Association has likewise lost a member whose record of thirty-four years of continuous service on one committee is surpassed by only three other members.

Since his connection with Committee 11 and the Association, Mr. Lehn saw many changes in the work of the committee. The first uniform classification of accounts had just been issued by the Interstate Commerce Commission, and railroad accounting, valuation and the keeping of records were not given the same serious attention as they are today. During discussions of the application of ICC accounting rules, the problems of the basic federal valuation and Order No. 3, Mr. Lehn always gave a practical and rational viewpoint to the committee's deliberations.

Mr. Lehn was known for his wit and humor, and was helpful in enlivening the committee proceedings at the appropriate time.

By his devotion to the work of the committee and his likeable personality he held the respect and friendship of all his associates, and it is with a sense of distinct loss to the Committee on Records and Accounts and the American Railway Engineering Association that the members of the committee here record his passing.

C. C. HAIRE
J. H. HANDE
J. H. ROACH
Committee on Memoir.

Report on Assignment 1

Revision of Manual

D. E. Field (chairman, subcommittee), F. B. Baldwin, H. D. Barnes, S. H. Barnhart, E. V. Braden, V. H. Doyle, E. M. Killough, C. A. Knowles, H. L. Restall, D. C. Teal.

Following the suggestion in the last paragraph of the report on revision of Manual in the 1941 Proceedings, the committee this year has planned a complete re-arrangement of all Chapter 11 material in the Manual, with the necessary renumbering of pages, forms and figures. Under this plan the chapter would be divided into three general sections:

1. General Records and Reports. (Pages 1 to 50, inclusive)
2. Roadway and Structures—Records and Reports. (Pages 51 to 150)
3. Office and Drafting Room Practice. (Pages 151 to end.)

Under this plan, also, gaps would be left in each section for future additions to the chapter, most of the anticipated expansion to fall under Section 3.

The rearrangement and renumbering of pages, forms, etc. are editorial changes and are of such a nature as not to require approval by convention action.

Report on Assignment 2

Bibliography on Subjects Pertaining to Records and Accounts

E. V. Braden (chairman, subcommittee), Anton Anderson, B. A. Bertenshaw, H. N. Halper, C. P. Richardson, D. C. Teal, A. O. Wolff.

This is a progress report, presented as information.

The practice of previous years has been followed in compiling the bibliography for the current year. Periodicals and reference lists of new books and pamphlets likely to contain articles pertaining to railroad records and accounts have been reviewed for items of special interest to members of the Association. The following is submitted as a result of such bibliographical review for the period November 1, 1940 to November 1, 1941.

Bibliography

Books

1. The Interstate Commerce Act—together with text of certain supplementary acts and related sections of various other acts—revised to April 1, 1941. Published by the Interstate Commerce Commission; 375 printed pp. Obtainable from the superintendent of documents, Washington, D. C. Price, 35 cents.

2. Accounting Classifications Governing Investment in Road and Equipment, Operating Revenues and Operating Expenses, Income, Profit and Loss, and general Balance Sheet Accounts, Train-miles, Locomotive-miles, Car-miles, prescribed by the ICC in accordance with Section 20 of the Interstate Commerce Act. Revised to January 1, 1941. 236 pp.

Available from Accounting Division, Association of American Railroads, Washington, D. C. Price, paper cover 25 cents per copy. This presents, in a single volume, the uniform system of accounts for steam railroads. It has been verified by the Bureau of Accounts with authentic records of the ICC.

3. Interpretations of ICC Accounting Classifications for Steam Railroads. Includes ICC Accounting Bulletin 15 and "A" cases issued by the Bureau of Accounts. Published in loose leaf form with indices, in 1940, by the Accounting Division, AAR, Washington, D. C. Price, $1 with binder and supplement. Supplement No. 1 covers revisions to March 1, 1941.

Pamphlets

1. Analysis of Accounting Practice in Railroad Abandonments of 1920–1940. By E. S. Lynch, assistant professor, Engineering Experiment Station, Iowa State College, Ames, Iowa. Bulletin 149, July 1940.

Sets forth typical reasons for the abandonment of 824.07 miles of line in State of Iowa in 20 years, then follows a critical analysis of methods of accounting therefor and concludes with a suggestion for modification of ICC requirements.

2. Railway Statistical Terms. A collection of definitions of words and phrases frequently used in discussions of railway statistics. By Bureau of Statistics, ICC, Washington, D. C., 58 mimeo pp. Statement No. 4119 dated June 1, 1941. Available on request to Bureau of Statistics, ICC.

3. Supplement No. 1 to Manual of Plans and Methods for Disbursement Accounting. Issued by the Accounting Division, AAR, April 1, 1941, 66 mimeo pp. Covers accounting for additions and betterments to roadway property by machine method, using punched cards and printing tabulator.

4. Cost of Railroad Transportation. Prepared by the Bureau of Railway Economics Library, AAR. 148 mimeographed pp. A bibliographical memorandum of some of the reports and discussions on this subject.

Periodicals

1. Letter of Edwin F. Wendt to Editor, Railway Age, V. 110 July 19, 1941. Submits William H. Taft's opinion that prospective earnings should be an element of value. This opinion of so distinguished a jurist is contained in "The Award and Reasons for the Award" in the Grand Trunk Arbitration Case. Ref: 31 Canadian Railway Cases 181, beginning on page 218. Also, 61 Dominion Law Reporter 672.

2. Treatment Accorded Stockholders in Current Railroad Reorganizations. By J. H. Parmelee, director, Bureau Railway Economics, AAR. Investment Bankers Association Publication, "The Economist", Dec. 10, 1940, pp. 22–24.

3. Determination and Forecast of Average Life. Plant retirement data; comparison of four methods based on the turnover principle. By P. H. Jeynes, Edison Electric Institute Bul. 9–9–13, January 1941.

4. Practice in Accounting for Depreciation. National Association Cost Accountants Bulletin 22: 947–63, Sec. 3, April 15, 1941; Abstract Management R 30: 183–4, May 1941.

5. Regulatory Aspects of Depreciation. By N. L. Smith, Edison Electric Institute Bul. 8: 567–71, December 1940.

6. Security Exchange Commission's Views on Depreciation Regarded as a Dividend Threat. Public Utilities 26: 869–71, December 1940.

7. Another Railroad Dilemma. New ICC demand creates hazard for receivership rails. By P. C. Anderson, Barron's 20:18, Dec. 30, 1940.

8. Use and Abuse of Depreciation. By J. H. Murdock, Jr., American Water Works Assn. Journal 32: 1647–65, October 1940.

9. Perennial Depreciation Problem. By H. L. Gary, Public Utilities 27: 401–10, March 27, 1941.

10. Railroad Construction Guide Prices. Compiled by the Engineering section of the Bureau of Valuation, ICC. 56 mimeographed pp., October 1, 1940. Includes map of the eight regions into which the country has been divided for statistical purposes.

11. Railroad Construction Indices. Compiled by Engineering section, Bureau of Valuation, ICC, Washington, D. C., 21 mimeographed pp., dated August 1, 1941. Includes map showing division of the country into regional groups for which indices have been established.

Report on Assignment 3

Office and Drafting Room Practices

D. C. Teal (chairman, subcommittee), B. A. Bertenshaw, D. E. Field, A. T. Hopkins, C. D. Johnson, W. M. Ludolph, F. M. Spiegel, H. J. Stroebel, H. C. Wertenberger.

This report is presented as information, with conclusions that are offered for adoption.

(a) Drafting Equipment and Tools

A report on this topic was made at the March 1940, convention and published in the Proceedings, Vol. 41, pages 454 to 456, as information. It contains a list of the drafting instruments and equipment ordinarily used and also general recommendations regarding the selection of new equipment.

This year your committee presents as information a description of some recent developments in drafting room technique.

Fluorescent Lighting

Among other important factors affecting the health, morale, efficiency and output of a drafting organization are the lighting facilities. Any improvement in lighting will be reflected in increased productivity and superior quality of the work.

Light is commonly measured by a unit called the foot-candle, which is equal to the light furnished by a standard one-inch diameter candle at a distance of one foot. This unit is used as a standard to calibrate light meters.

On a bright day the sun produces about 10,000 foot-candles of illumination. In shade this is reduced to about 500 and even on a cloudy day there are several hundred foot-candles outdoors. Comparing this with the natural daylight in modern office buildings, there is a surprising contrast. The light meter will register only about 100 foot-candles near windows on sunny days. On cloudy days it is much less. As the meter is moved away from the window, it may show only 20 foot-candles or even less.

The question to be answered is, how much light is necessary for efficient work in the drafting room. Extensive experiments indicate that the average choice of a great many eyes of all ages for close work, ranges from 75 to 300 foot-candles and is an illumination several times higher than that commonly found indoors. As a result of these studies, the electrical companies recommend from 75 to 100 foot-candles illumination on drawing tables for best results.

Lighting factors other than the number of foot-candles, have to be considered in the drafting room. They are: Glare and its effect on the eyes and vision, shadows, diffusion, direction, and color quality of light, all of which enter into the problem.

It is claimed by the manufacturers that the development of fluorescent lighting has brought about a virtual revolution in the lighting field, that it has created new standards of lighting effectiveness and that fluorescent lamps and reflectors excel the old style electric lights for the following reasons:

1. More economical to operate.
2. Greater efficiency, maximum horizontal and vertical illumination at minimum costs.
3. More effective distribution by reason of the extended light source.
4. Higher intensity of illumination and elimination of flicker.
5. Furnish cool, glareless light.
6. Eliminate shadows.
7. Attractive appearance.
8. Allows choice of white, day or other tinted light colors to ease eyestrain.
9. Approved by the National Board of Fire Underwriters, Inc.

If the manufacturer's claims are correct, it would seem that fluorescent lighting would be particularly adaptable to drafting room work in that the proper combination of lamps, reflectors and mountings would provide the important qualities of high illumination and elimination of shadows and glare.

However, all of the manufacturers' claims have not yet been proved. Fluorescent lamps, reflectors and other appurtenances cost considerably more than the old style incandescent equipment. This, of course, increases the investment cost and carrying charges which offset the lower operating costs of the fluorescent lamps.

The manufacturers recommend that lamps be purchased that are rated 30 percent above the foot-candle illumination desired in order to make allowance for depreciation of their effectiveness which occurs shortly after installation. Experience up to the present time demonstrates that the life expectancy from fluorescent lamps is less than that given by comparable incandescent types.

Fluorescent lights give a more effective distribution than other types, as they are designed especially for this quality. However, this extended light source often makes it necessary to install more units in order to create the same amount of light at a given point as would be received from an incandescent type.

The fluorescent lamp is especially designed to eliminate flicker and accomplishes this result. The elimination of shadows, which depends mostly upon the number and arrangement of lamps and reflectors, can be accomplished by the proper combination and arrangement of incandescent lamps and reflectors as well as by the fluorescent type.

Fluorescent lights emit less heat than incandescents, and this factor can be important in hot weather. Opinions differ as to the attractiveness of appearance of the two types. The appearance largely depends upon the amount of the investment.

A canvass of users reveals an approximately "fifty-fifty" division of opinion as to the merits of fluorescent lighting. An inspection was made of a drafting department, located in two rooms, one of which was equipped with fluorescent and the other with incandescent lighting fixtures. The draftsmen in this department were unanimous in their preference for the incandescent lighting. However a check with a light meter, revealed that due to poor choice of type and arrangement of reflectors, and to an insufficient number of units, the illumination on the tables in the room with fluorescent lights was only 50 foot-candles while the incandescents furnished 80 foot-candles.

Your committee offers as its conclusions:

1. Fluorescent lighting is still to some extent in the experimental stage.

2. The superiority of fluorescent lighting over other types, for use in the drafting room is not yet definitely established.

3. Satisfactory lighting can be had with either the fluorescent or incandescent types if properly designed and installed to meet the visual requirements.

Float Lettering

For maps and drawings that are to be reproduced by the photo-lithographic process, it is desirable to have mechanically perfect letters and figures of different styles and sizes. The float letter method is one way of achieving this result.

This process is an adaptation of the paster method in which the lettering is first printed on paper, then cut out and pasted on the map. It differs from the old paster method in that the tissue on which letters are printed is very thin and practically transparent and after drying becomes more or less integral with the drawing paper. As indicated by the title, the tissue with the lettering on it is literally floated into place after brushing water over the surface of drawing. In this manner the lettering can be placed in the exact spot desired.

There are three essential steps to this operation, first, classification of the lettering into type, styles and sizes; second, printing the words on the tissue and coating the underside of it with a gum solution; and third, floating the printed matter to the position desired on the drawing.

The float method of applying lettering is a patented process and may be used only upon obtaining a license from the inventor, which costs about $500. With it, however, are furnished the coating equipment, tools for floating, formulas, a booklet of instructions and information in respect of other materials to be purchased.

To achieve the greatest efficiency, a small, hand-operated printing outfit should be included in the equipment. A 3-in. by 5-in. bench model press is usually satisfactory although a 5-in. by 8-in. size will accommodate scale bars, title lines, symbols, etc., that would have to be cut into sections on the 3-in. by 5-in. press. Six to ten styles of type in from three to five sizes ranging from 10-point to 36-point will generally meet all requirements.

Press and type will cost about $600, which, together with the patent fee of $500, makes a total cost of approximately $1,100 which limits the use of the process to large and important jobs. However, on extensive United States Geological Survey work and U. S. Army Engineering Survey maps, it is claimed that the cost of the float method is 50 percent of the cost of lettering by hand.

Drawing Projectors

In order to speed up the production of aircraft for national defense, certain plane manufacturers are using giant cameras to photograph airplane plans, which may be drawn to any convenient scale. The picture of the drawing is then projected on sheets of metal whose surface has previously been sensitized with a special emulsion. The reproduction on these sheets, later to become a part of the plane, then are "developed" in huge tanks. The metal is then cut out in accordance with the markings.

The cameras used are the world's largest, making pictures five by ten feet or larger. The method is an adaptation of the well known photostatic process. It is claimed that weeks of time formerly required for tracing work and pattern cutting are saved by this method.

Microphotographic Cameras for Office Use

Although not in common service, the microphotographic camera is now used in some railroad offices for photographing newspapers, manuscripts and other records, and may eventually find its way into the drafting room. The photographic copies made with such a camera require only a small fractional part of the storage space which would be required if the original record were filed.

A number of large newspapers have adopted the idea as a means of meeting the problem of finding space for their files of back copies. The pages can be photographed at the rate of 20 per min. and approximately 825 pages of newspaper can be recorded on a 100-ft. roll of film that takes up little more space than a package of cigarettes. The film, which is non-inflammable is filed in fireproof vaults. When required for reference, the pages are reproduced in full or in part on a screen to any desired enlargement by means of a picture projector. In this manner thousands of cubic feet of storage space have been recovered for other uses.

Most of the United States Government offices in Washington, and many state and city libraries, have invested in microphotographic equipment for other reasons, such as to photograph manuscripts and other valuable records whose loss would be irreparable, and so, to have exact copies available in case anything should happen to the original. In addition to preserving old manuscripts in danger of deterioration from age, the process also makes it possible for libraries to obtain copies of manuscripts or documents which cannot be bought. According to the United States Bureau of Standards the life of the film used in microphotography is equal to that of the best grade of paper and that the pictures made today, if stored properly, will be readable in the year 2042.

The essential equipment required for microphotographic work, is the special camera, a film reader or projecting machine, and a projector printer for making copies. If desired and with proper dark room facilities, the pictures can be developed where taken. The cost of facilities will vary with the completeness of the layout and quality of the equipment. The camera may be rented, if so desired. Owing to present lack of standardization which is partly due to the newness of the process and to experimental research still in process, your committee has not attempted to estimate the costs involved. The size of film commonly used is 35 mm., of the type used in moving picture work, in 100-ft. rolls which when wrapped on spools, occupies a space approximately 1¾ in. by 3½ in. diameter and is ordinarily placed in 2 in. by 4 in. by 4 in. cardboard boxes. In one Washington, D. C. government office (The Bureau of Census) records occupying 7,000 sq. ft. of space have been reduced by microphotography to 12 filing cabinets occupying 50 sq. ft.

During the first ten years or so after the organization of a drafting room, the filing of drawings is a comparatively easy matter. Most of the drawings are used infrequently, and if filed and indexed with reasonable efficiency, can be readily found. However, with the passing of time, more and more of these drawings and records are seldom used and the originals become tattered, faded and hard to read, and as their number increases it may be necessary to obtain additional filing equipment and storage space. It may be problematical whether some of them will ever be used again; however, the original or an authentic reproduction must be kept for possible future needs. Microphotography meets these needs.

Although there is no record of microphotography being used now by railway drafting offices, the time may come when file rooms will become so filled with bulky, inactive and disintegrating drawings that the adoption of something on this order will become advisable.

(b) Specifications of Materials to be Used for Drawings and Drafting

A report on this topic was made at the March, 1941, Convention and published in the Proceedings, Vol. 42, pages 373 and 375, as information. The conclusions submitted were:

1. Except for requirements laid down to the paper mills by the drawing supply companies, there are no specifications now in use or available for the ordering of drawing and drafting materials.

2. The present, almost universal practice of ordering "trade name" materials by catalog reference and from samples, limiting the selection to standard types having general quality and properties suited to the major requirements of the office, is quite satisfactory for railroad work.

In order to provide reference, more readily available, to this information, your committee recommends that the above conclusions be published in the Manual.

(c) Standard System for Filing Drawings

A report on this topic was made at the March, 1941, Convention and published in the Proceedings Vol. 42, pages 375 to 378, as information. It describes the various methods and equipment used by railroad offices. In the opinion of the committee, standardization of methods is impractical because of the differences in individual requirements.

Your committee has reviewed the subject matter, reaffirms its opinion and recommends that the subject be discontinued.

Report on Assignment 4

Recommended Practice to Be Followed With Respect to Maintenance of Way Accounts and Statistical Requirements

H. L. Restall (chairman, subcommittee), Anton Anderson, E. V. Braden, W. F. Cummings, C. D. Johnson, W. M. Ludolph, W. S. McFetridge, A. T. Powell, D. C. Teal, A. O. Wolff.

The following report is presented as information.

Your committee has had under study a system of recording the characteristics and location of electrical equipment and desires to call attention to the necessity for such a record and to recommend a system which will record the pertinent facts.

It has been demonstrated by floods, hurricanes, fires and operating emergencies arising from other causes, that many carriers do not have at headquarters records with information in sufficient detail to permit of immediate field replacement of electric motors and transformers. Furthermore, inasmuch as no change in the investment account is required under the terms of the $500 minimum rule in the classification of accounts of the Interstate Commerce Commission many carriers will not make a record of property changes when new motors are acquired or old ones replaced. For this reason this recommended record is invaluable in order to locate this class of property.

Several methods for identification of the units are in use at present, among which are stamping or painting a number on the motor, and tapping a number plate to the unit. The latter method is recommended because it is a separate identification and not

apt to be confused with other numbers already on the unit; also it is a more enduring fixture. After some study, with typing and codes to denote classes and kinds, it is the opinion of the committee that numbering in sequence best meets the requirements; the original number assigned to be continued as long as the motor lasts, then to be discontinued.

After study of the various kinds of records in use, your committee suggests a card record for each unit. This method has many advantages over a ledger or book record, in that it has greater flexibility. A suggested form for the face of the card is shown in Fig. 1. Additional data may be recorded on the reverse side of the card.

Location	Number .....
"	Serial No. .....
"	Frequency .....
Mfr.	Phases .....
Model	Speed Full Load—R.P.M. .....
Type	.....
Form	Cost .....
Voltage	A.F.E. No. .....
Amperes	Use .....
H.P.	" .....
Date Installed	" .....
" "	
" "	

Fig. 1.—Suggested Form for Card Record of Motors.

To properly maintain the record, instructions should be issued to the effect that anyone having occasion to make any change in motors, should notify headquarters immediately. A method which has worked successfully is a form postcard addressed to the office responsible for the maintenance of the record on which the change and the reason therefor are reported. The card should be forwarded to headquarters whenever a motor is installed, removed or received. Occasionally more than one post card, per-

No..... Date..... Removed from .....
No..... Date..... Installed at .....
No..... Date..... Shipped to .....
No..... Date..... Received from .....
Facility affected .....
Reason for movement .....
Requested by .....
Remarks .....
.....
.....
Signature

Fig. 2.—Postcard Form for Reporting Transfer of Motors.

taining to an individual motor, will be received, which acts as a double check for headquarters. A suggested form for the postcard is shown in Fig. 2.

All spare units in stock should be recorded in the same manner as though in service, thereby giving headquarters information of the type and units available for use.

The system is applicable to transformers as well as to motors.

This record is not intended to include motors on office equipment, wayside signal apparatus, small hand tools or rolling stock.

Report on Assignment 6 (a)

Résumé of Developments of the Current Year in Connection with Regulatory Bodies and the Courts

S. H. Barnhart (chairman, subcommittee), F. B. Baldwin, H. D. Barnes, B. A. Bertenshaw, W. C. Bolin, V. H. Doyle, D. E. Field, C. C. Haire, H. N. Halper, A. T. Hopkins, W. R. Kettenring, E. M. Killough, C. A. Knowles, P. R. Leete, D. O. Lyle, W. S. MacCulloch, H. L. Restall, H. J. Stroebel, V. P. Turnburke, H. C. Wertenberger, Louis Wolf.

Your committee offers the following progress report as information:

The Interstate Commerce Commission's order of June 16, 1941, amended the effective accounting classifications for steam railroads to correspond with its decision in Ex Parte 138, *Opening Journal Entries for Reorganization of Chicago Great Western Railroad Co.* This decision and order lend further importance to building up a proper statement of original cost from the carrier's valuation records. The Commission's decision was to the effect that railroads emerging from bankruptcy proceedings under Section 77 should record on their books for road and equipment property, the estimated original cost as determined under the Commission's valuation proceedings, with an offsetting entry to an account entitled "Reorganization Adjustment" to record the difference between the original cost figure and the cost of acquired property. The general order issued on all carriers prescribed this method for all purchases, mergers and acquisitions of complete segments of railroad property.

The Interstate Commerce Commission appropriation for the fiscal year beginning July 1, 1941, includes $640,000 for its Bureau of Valuation, the same amount as for the previous year. On October 1, 1941, the total force of the Bureau numbered 189 employees.

During the year 1940 Class I railroads charged to Account 459, "Valuation Expenses", an amount of $561,033, contrasted with $425,589 for the year 1939.

During the year consideration was given to an order issued by the Director of Valuation requiring carriers to file BV Form 588 returns by June 1 of each year, or in lieu thereof to file a return on BV Form 589 by March 1. June 30, 1942 was the date set by which all arrearages in filing the 588 returns must be made up. The occasion for the order was that carriers were delinquent from 2½ to 3 years in the filing of the 588 returns. The matter was brought to the attention of Mr. E. H. Bunnell, vice-president, FAT&V Department, Association of American Railroads, by appropriate resolution pointing out the impossibility of complying with this new order. It is understood that similar action was taken by the Accounting Division of the AAR. Following conferences between Mr. Bunnell and the Commission's representatives, a modifying order was issued fixing December 31 of each year as the date by which 588 returns for the previous

year must be filed and setting October 1, 1941 as the date for filing 589 returns if the 588 return could not be made for 1940 or prior periods by the required dates. December 31, 1942 is the date by which all arrearages in 588 returns must be made up, after which time it is required that carriers shall file these returns when due.

These returns on BV Form 588 contain the details of property changes required by the Bureau of Valuation to bring previous engineering inventories forward to new valuation dates. The Land and Accounting Sections of the Bureau also utilize them to bring to date their land reports and statements of original cost, respectively. As of October 1, 1941 all Class I carriers had filed 588 returns through the year 1935; 99 percent through 1936; 97 percent through the year 1937; 91 percent through the year 1938; 69 percent through the year 1939; and 39 percent through the year 1940; or were approximately 94 percent* current.

The Engineering section of the Bureau of Valuation, having completed revised inventories for all carriers through 1927, is engaged in bringing these inventories forward to later dates, and as of October 1, 1941 had completed 68 percent of the mileage through 1932; 35 percent through 1934; 8 percent through 1936; 1 percent through 1938; or was approximately 61 percent* current.

The work of the Accounting section in preparing summaries of original cost, and that of the Land section in revising land valuations, has advanced to about 55 percent* and 69 percent* respectively.

No tentative valuations as of current dates were completed and served on railroad companies, but at the request of the Commission, the Bureau brought to date the underlying valuation estimates of carriers involved in reorganization proceedings. In a number of cases carriers checked these estimates of original cost plus the reproduction new, less depreciation and land value.

In connection with Docket 28300, *Class Rate Investigation,* the Bureau of Valuation brought all the elements of value of Class I railroads up to January 1, 1940. In this case, and in Docket 28190, *New Automobiles in Interstate Commerce,* in which 38 carriers representing possibly 75 percent of the railroad plant of the country are involved, the call of the Commission on the Bureau of Valuation was for "recommended values" instead of just the standard elements of value, for use in cost of service analyses by the cost branch of the Commission. The aggregate of these values for Class I roads is about 9 percent less than the total value in Ex Parte 123 three years earlier. The Commission has pointed out that the continuous valuation records are being found practical, because of the slight delay and small cost in making new valuations, not only in rate cases but in division cases, joint rail and barge rates, and divisions and division adjustments; and also for various national defense and planning projects.

The Commission also has stated that the continuous records likewise have made possible the ascertainment of original cost which they were unable to determine at the time of the original or basic valuations. Inasmuch as 25 years ago few railroads had records of original cost, the Commission has adopted the cost of reproduction new, at so-called 1914 normal prices, as the best estimate of original cost of the property as of basic valuation dates. Twenty-five years of annually (1) deducting retirements at the 1914 normal prices, and (2) taking in new property at cost, have given a record of original cost for approximately 75 percent of the property. The 1914 reproduction cost still stands for the remaining property, and that is reduced year by year. For this reason original cost is now stated as a fact by the Commission in exhibits showing the elements of value.

* Based on six million mile-years from basic valuation through 1940.

Court Decisions

There were no noteworthy decisions by the U. S. Supreme Court involving valuation issues since the last report was prepared. A number of utility cases involving rates were litigated in state courts, but no new issues were decided. It is known that many states are adopting the continuous inventory system similar to that adopted by the Interstate Commerce Commission for railroads, and they state it has proved effective in reducing the time and effort required in making revaluations of utility properties for regulatory purposes.

The Federal Communications Commission instituted an investigation, without fixing a definite date for hearings, upon the American Telephone and Telegraph Company, and its associates, with inquiry as to what should constitute the rate base for telephone rates. In answering one query, "What method is to be adopted in arriving at the rate basis?", the A. T. & T. and associated companies replied that they adhered to the Smyth vs. Ames rule, including the element cost of reproduction new. In answer to another query, "What method is to be used in arriving at the accrued depreciation of property?", they replied that the method of field inspection and study of property to ascertain among other things "wear and tear, decay, action of the elements, inadequacy, obsolescence, changes in the art, and changes in demand and requirements of public authority" and other losses that are known to be operating, against which the utility is not protected by insurance, should be used.

The Commission asked whether it would be fair to (a) company, (b) investors, and (c) customers, if original cost were adopted as the gross rate base to the exclusion of reproduction cost (before any deduction for accrued depreciation is made) in the development of reasonable rates for long-lines department service.

The telephone company answered that if the question is directed to a determination of rate base, all properties used and useful in rendering service, at original cost, as distinguished from determination of fair value, based, among other things, upon reproduction cost new, the answer is that it "would be unfair."

The telephone company asserted that it was not unmindful of the criticisms which had been made of the delays and expense incident to the presentation of the usual forms of proof, but insisted that the Commission had the duty of inquiry while the "utility has the right to be heard." It asserted it was willing to enter into stipulation as to certain matters.

Responding to the question propounded by the Commission of "whether it would be unfair if the original cost of telephone property were adopted as the gross rate base to the exclusion of reproduction cost," the telephone company asserted it would have no bearing on the necessity of presenting evidence as to the reproduction cost new of the property involved. It argued that for the respondents to reach the conclusion that evidence of cost of production new was not proper, would result, in effect, in respondents consenting to follow any order the Commission might make prescribing rates. Consequently, the "omission of such evidence would be most unfair to the respondents and the investors as well as unwise and unlawful."

Respondents stood for reproduction of existing plants as against a "hypothetical or substitute plant capable of rendering the same or similar service."

Report on Assignment 6 (b)

ICC Valuation Orders, Reports and Records

The subject of "Study of Valuation Order No. 3 Reports and Records to determine if further simplifications are possible" has had continued and careful consideration by this committee. Many suggestions have been offered and debated during the year, but no specific changes in requirements have developed.

The subject of "Form of Order No. 3 Reports in connection with joint projects, Federal–Railroad" was continued for further consideration this year. Delay in progressing this subject has been due to indecision by the Bureau of Valuation or the Commission as to how such projects are to be treated for valuation purposes. During this year a conclusion has been reached with respect to overhead highway crossings, and Mr. Carroll Miller, ICC commissioner in charge of valuation, instructed Director Lewis that until further advised, the Bureau of Valuation should be guided by the following procedure dealing with overhead highway crossings in bringing forward its inventories of physical property of the railroads and in preparing cost of reproduction and original cost summaries and reports:

> 1. *Cost of Reproduction New.*—The cost of reproduction new shall be the actual amount borne by a carrier for the cost to it of construction of physical property incident to, or in connection with, the construction of overhead crossings formerly includible in old Account 15, Crossings and Signs, now includible in Account 39, Public Improvements—Construction, as provided by the Commission's accounting classification for investment in road and equipment. The property referred to in the foregoing shall not be considered as depreciable property for valuation purposes.
>
> 2. *Original Cost.*—The original cost shall be the actual amount borne by a carrier for the cost to it of construction of physical property incident to, or in connection with, the construction of overhead crossings formerly includible in old Account 15, Crossings and Signs, now includible in Account 39, Public Improvements—Construction, as provided by the Commission's accounting classification for investment in road and equipment. The property referred to in the foregoing shall not be considered as depreciable property for valuation purposes.
>
> The foregoing make unnecessary Engineering Section reports on cost of reproduction, both new and depreciated, of such overhead grade separation.

In line with the foregoing, the Bureau of Valuation has also ruled that items of property changes involved in undergrade crossings, such as paving of streets, sidewalks, sewer systems, etc., which, under the Commission's classification of accounts, are properly chargeable to Account 39, Public Improvements—Construction, shall be handled likewise.

These instructions seem to solve the problem of valuation reports for overhead highway crossings. This committee does not think it necessary to develop any specific "form" of report and recommends that this phase of the subject be discontinued, but that the general subject be continued for further consideration of form of reports for other items such as undergrade crossings, etc.

In the case of Western Pacific Railroad Company undergoing reorganization under Section 77 of the Bankruptcy Act, a plan of reorganization had been approved and certified to the Court by the Interstate Commerce Commission, as required by the stat-

ute. The carrier, as well as a number of other interested parties, including the Western Pacific Railroad Holding Company, the Reconstruction Finance Corporation, the Railroad Credit Corporation, instituted a suit in the U. S. District Court to have the proceedings set aside. The District Court accepted the plan of the Commission but upon appeal the U. S. Circuit Court of Appeals for the Ninth District, at San Francisco on November 28, 1941, held that instead of approving the plan, the lower Court should have entered an order dismissing the proceeding or referred it back to the Commission for further action. The Circuit Court held that it was necessary to determine the value of the new first mortgage bonds, income bonds, new preferred stock and new common stock, and to do this it was necessary to determine the value of the debtors' entire property subject to the mortgages, as well as the value of the various claims submitted in the reorganization proceeding.

The Court of Appeals said, among other things, "it thus becomes the duty of the Commission to determine these values and certify them to the Court. That duty was not performed.

"Lacking the requisite valuation data the Court was in no position to exercise the 'informed independent judgment' which appraisal of the fairness of a plan of reorganization entails."

The opinion concluded by reversing the order and remanded the proceedings with directions to dismiss it or, in the Court's discretion and upon motion of any party in interest, to refer it back to the Commission for further action.

Report on Assignment 7

Report Upon Changes In, Revisions and Interpretations of, ICC Accounting Classifications

H. D. Barnes (chairman, subcommittee), F. B. Baldwin, S. H. Barnhart, W. C. Bolin, C. C. Haire, J. H. Hande, W. R. Kettenring, W. M. Ludolph, O. M. Miles, H. L. Restall, C. P. Richardson, V. P. Turnburke.

This report is submitted as information with the recommendation that the subject be continued.

Your committee has reviewed proposed accounting orders or rulings submitted by the ICC Bureau of Accounts.

In accordance with the plan which has been followed for a number of years summaries of the opinions of the members of the committee have been furnished Mr. E. H. Bunnell, vice-president, Association of American Railroads, for the subjects as follows:

ICC Bureau of Accounts Subject No.	*Subject*
247	Proposed order modifying Sections 7 and 8 of the General Instructions in the Classification of Investment in Road and Equipment to provide that all retirements of road property, except important sections of the main line, or a branch line, shall be charged to Operating Expenses.
253	Proposed order modifying the Classification of Investment in Road and Equipment and Operating Revenues and Operating Expenses to provide

that the total cost of all Additions and Betterments to existing tracks, except the installation of ballast in tracks not previously ballasted, shall be charged to Operating Expenses.

258 Proposed order modifying the accounting classifications to substitute the group method for the unit method of depreciation accounting as an optional provision for roadway property.

291 Proposed "A" case specifying the accounting by the lessee for improvements to leased property when the cost of the improvements are refunded by the lessor periodically during the term of the lease and at the termination of the lease and when the lessor is an affiliated company.

292 Proposed amendment to paragraph (b) of the answer to Class A–10 (Revised).

295 Proposed "A" case defining the accounting when a box car is converted to work equipment without physical change.

298 Proposed "A" case providing that the cost of filling sink holes on the right-of-way caused by the caving in of abandoned coal or other mines.

In addition to these subjects the following were in the hands of the committee for review at the time this report was prepared:

ICC Bureau of Accounts Subject No.	*Subject*
291 Revised	See Subject 291 above.
296 Revised	Proposed revision of the answer to Case A–113
303	Proposed "A" case prescribing the accounting for the cost of replacing bridges supporting tracks over highways, canals, or other passes when all or part of the cost is borne by governmental authority.
304	Proposed "A" case specifying the account to which the salaries of division accountants and their staffs shall be charged when located in the offices of division superintendents, master mechanics, roadmasters, etc.
305	Proposed order modifying the text of Sections 4 (a) and 4 (d) of the General Instructions in the Classification of Investment in Road and Equipment, eliminating Note B to Account 9, Rails, and creating a new general and primary Account 80, Construction Work in Progress.
306	Proposed "A" case prescribing the accounting for the cost of labor and materials used to stabilize the subgrade of roadbeds due to water pockets.
307	Proposed order canceling Account 4, Underground Power Tubes, in the Classification of Road and Equipment, and Account 204, Underground Power Tubes, and 205, Underground Power Tubes—Depreciation, and providing for the charging of costs previously chargeable to Account 4 to Account 31, Power Transmission Systems.
308	Proposed "A" case specifying the accounting for assembled spare parts for Diesel electric locomotives.

Since this committee's last report (Proceedings for 1941, Vol. 42, pages 382 to 385) the ICC has issued the following orders, of interest to engineers, modifying the accounting classifications:

Order dated December 18, 1940, effective January 1, 1941, modifying the last two paragraphs of Section 2 of General Instructions in Classification of Investment in Road and Equipment defining "cost"; modifying text of Road and Equipment Account 2½, Note B, Account 6 and Note A, Account 39; and addition of note to Balance Sheet Account 754.

Order dated December 26, 1940, effective January 1, 1941, modifying the texts of Road and Equipment Accounts 21, Grain Elevators and 22, Storage Warehouses; Section 4 of General Instructions in Classification of Operating Expenses; the text of Accounts 433, Incidental, and 446, Other Miscellaneous Operations; and the text of Account 705, Miscellaneous Physical Property; and canceling Cases 178 and 250 of Accounting Bulletin No. 15.

Order dated June 16, 1941, effective June 1, 1941, modifying Section 1 of the General Instructions in Classification of Investment in Road and Equipment; canceling Account 41, Cost of Road Purchased; modifying the title and text of Account 42, Reconstruction of Road Purchased; the title and text of Balance Sheet Account 701, Investment in Road and Equipment; the text of Account 702, Improvements on Leased Property; creating a new Account 702½, Acquisition Adjustment; and canceling Account 757½, Reorganization Adjustments of Capital.

Order dated July 15, 1941, effective January 1, 1942, modifying paragraphs (c) and (e) of Section 4 of the General Instructions in the Classification of Investment to eliminate rent or return on the investment in equipment, and charges for transportation of men, material and equipment over a carrier's own line; and modifying the text of Account 76, Interest During Construction, to eliminate interest during construction during the construction period on the carrier's own funds; General Account VIII, Transportation for Investment–Cr., is canceled and appropriate changes made in the Income Accounts; Case 177 of Accounting Bulletin 15 is canceled.

Order dated August 6, 1941, effective January 1, 1942, modifying the list of units of passenger train cars in the text of General Account II, Equipment, and specifying numerous changes in the Income and Balance Sheet Accounts with appropriate changes in Accounting Bulletin 15.

Order dated September 22, 1941, effective January 1, 1942, establishing Accounts 270½, Road—Amortization of Defense Projects, and 331½, Equipment—Amortization of Defense Projects in the Classification of Operating Revenues and Operating Expenses; and Accounts 725½, Accrued Amortization of Defense Projects—Road, and 776½, Accrued Amortization of Defense Projects—Equipment.

Order dated September 23, 1941, effective January 1, 1942, modifying Section 11 of the General Instructions in the Classification of Investment in Road and Equipment and Section 7 of special instructions pertaining to Operating Expenses in the Classification of Operating Revenues and Operating Expenses pertaining to the transfer of a unit of equipment from one class of service to another without physical conversion.

The following order and notice have also been issued during the past year:

Order dated February 7, 1941, superseding order dated June 7, 1937 relating to applications under Section 1, paragraphs (18) to (20), inclusive, of the

Interstate Commerce Act for certificates of public convenience and necessity authorizing the construction, extension, acquisition or operation of lines of railroad.

Notice dated April 7, 1941 from the secretary of the ICC transmitting letter from the director of the Bureau of Valuation in regard to the filing of returns on B. V. forms 588 and 589. This notice was modified by a later notice by the Secretary dated July 8, 1941.

In addition to these orders the Bureau of Accounts has released the following new and revised rulings:

Issued January 1, 1941

Case A–3—Revised, accounting for installation of treated timber in place of untreated timber in the repair of bridges.

Case A–10—Revised, accounting for investment in and rental from structures, except grain elevators, and storage warehouses which are not used by it or another common carrier in transportation service or in service incidental thereto.

Case A–21—Revised, accounting for retirements of leased carrier property, the cost of additions and betterments to which are charged Account 702, Improvements on Leased Property.

Case A–24—Revised, accounting for investment in carrier facilities upon land leased from a non-carrier.

Case A–49—Revised, interpretation of minimum rule contained in Section 2 of the General Instructions of Investment in Road and Equipment in connection with joint expenditures.

Case A–57—Revised, accounting for property included in Account 779, Additions to Property Through Income and Surplus.

Case A–108—Revised, accounting for depreciation on improvements to leased freight train cars charged to Account 702, Improvements on leased Property.

Case A–126—Revised, accounting for rent and repairs of a pole line owned jointly by the carrier and a telegraph company.

Case A–160—Revised, accounting for payments made under the so-called "Washington Agreement of May 21, 1936."

Issued January 25, 1941

Case A–94—Revised, pertains to disposition of balance remaining in Account 15, Crossings and Signs as of December 31, 1935, which was canceled as of that date.

Case A–103—Revised, accounting for overheads in connection with the construction of an undergrade crossing at the expense of a public authority or a spur track at the expense of an industry.

Case A–105—Revised, accounting for labor expense incurred in connection with "Betterments".

Case 109—Revised, accounting for the replacement of an overhead highway bridge at the expense of a public authority.

Case A–110—Revised, accounting for the elimination of a highway grade crossing by the construction of an overhead bridge.
Case A–111—Revised. Canceled.
Case A–112. Canceled.
Case A–122. Canceled.
Case A–137—Revised. Canceled.
Case A–144. Canceled.

Issued May 15, 1941

Case A–51—Revised, accounting for royalties received from oil wells located on a carrier's right-of-way.
Case A–162, equalization of maintenance expenses.
Case A–163, provides that only transportation charges paid foreign lines for transporting the material up to the carrier's line are includible as part of the cost of material.

The F. A. T. & V. Department of the Association of American Railroads published the accounting classifications revised to January 1, 1941, and issued revised pages for the loose leaf binding of Bulletin No. 15 and subsequent "A" cases.

Depreciation Accounting for Roadway Property

The present accounting classifications of the Interstate Commerce Commission provide for optional depreciation accounting upon selected items of roadway property, and carriers have not generally exercised this option, but instead, use the retirement method of accounting.

Under the provisions of an order adopted in 1931, it is required that depreciation accounting be mandatory upon all classes of property embraced in certain accounts, but this order has never become effective.

Recently the Bureau of Accounts of the Commission has submitted a proposed accounting order making the provisions of the order in Docket 15100 effective as of January 1, 1942. At the direction of the Board of Directors of the Association of American Railroads, the officers of that association, in conjunction with appropriate committees, have been giving consideration to the terms of the proposal and several conferences have taken place with representatives of the Commission.

At the time this report is submitted, the final outcome of the negotiations is not known, nor are the classes of roadway property on which depreciation accounting will be mandatory.

Report of Committee 3—Ties

John Foley, *Chairman,*
R. S. Belcher
W. C. Bolin
W. H. Brameld
H. F. Brown
W. J. Burton
R. E. Butler
F. G. Campbell
S. B. Clement
R. L. Cook
E. J. Cullen
H. R. Duncan
W. E. Gardner
W. R. Gillam
B. D. Howe
C. T. Jackson
J. E. Lockhart
Roy Lumpkin
W. D. Simpson, *Vice-Chairman,*
A. F. Maischaider
E. F. Salisbury
Raymond Swenk
Sverre Thorvaldson
C. D. Turley
A. W. White
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Recommended revision submitted in report on Assignment 5.

2. Extent of adherence to specifications.

   Progress report—presented as information below.

3. Substitutes for wood ties.

   No report.

4. Tie renewals and costs per mile of maintained track.

   Progress report—presented as information ..... page 400

5. Investigate and report on the dimensions of ties, and bring up-to-date the information presented in the 1924 and 1932 Proceedings.

   Final report, submitted for adoption ..... page 401

6. Cause and control of splitting in railroad ties.

   Progress report—presented as information ..... page 401

The Committee on Ties,
John Foley, *Chairman.*

Report on Assignment 2

Extent of Adherence to Specifications

W. D. Simpson (chairman, subcommittee), R. S. Belcher, W. C. Bolin, W. H. Brameld, H. F. Brown, F. G. Campbell, R. L. Cook, E. J. Cullen, H. R. Duncan, W. E. Gardner, B. D. Howe, C. T. Jackson, Roy Lumpkin, E. F. Salisbury, Raymond Swenk, Sverre Thorvaldson, C. D. Turley, A. W. White.

This is a progress report, presented as information.

Two trips of observation were made during 1941, to the yards of five wood-preserving plants, where the ties of five railroads were seasoning.

The stacks viewed ranged from 250,000 to 810,000, and totalled 2,165,000 ties. All the ties were produced adjacent to the lines of the railroads which owned them, in the uplands of the Allegheny area of five states in the central, eastern and Pocahontas regions. Only hardwood ties were in the stocks looked over, and few of them were other than oak.

The five railroads purchased their ties under AREA specifications and adhered closely to the standard. Three of the railroads in one case and two in another could be considered competitive in their procurement, since their sources of supply to some extent are contiguous or overlapping. Their maintenance in both cases of a practically uniform standard of inspection and satisfactory adherence to specifications demonstrates that railroads do not have to depart from standards in order to procure ties.

Two of the yards had previously been visited in 1929, and the present ties are markedly superior to those seen then, at which time acceptance was not governed by AREA specifications. Corresponding improvement in conditions has taken place in the yard of one railroad which needed to make a change. All five yards were in creditable condition as to freedom from debris, though one had a spot of vegetation which should have been removed before it probably was pulled.

In only two yards were hewed ties present in appreciable numbers; 25 percent in one, and 50 percent in the other. Poor manufacture characterized the hewed ties, which were generally rough (uneven surfaces), often inadequately peeled, and frequently excessively thick. In both yards the hewed ties were made in the unworkmanlike manner typical of the territory producing them. The quality of the wood available is excellent. It is no more cross-grained or knotty than wood made into ties elsewhere, but the scarcity of adept axmen is apparent by the few smoothly-surfaced ties. The advent of machine adzing has caused some railroads to become, seemingly, indifferent regarding the extent to which the tops and bottoms of ties are uneven or out of parallel, and in consequence the hewers of ties in certain sections are far more careless than formerly Slip-shod manufacture will continue as long as railroads tolerate the acceptance of mismade ties.

Report on Assignment 4

Tie Renewals and Costs per Mile of Maintained Track

John Foley (chairman, subcommittee), S. B. Clement.

The data regarding crosstie renewals reported to the Interstate Commerce Commission by railroads in the United States and to this Association by the railroads in Canada are presented in the folded inserts (Tables A and B for 1940 statistics and Table C for the last five years and the average of them). To make this information available as soon as practicable, it was given advance publication in Bulletin 425, June–July, 1941.

Totals for each region and for the United States have been included for the first time, as of interest to students of the subject when making comparisons. However, attention is again called to the need for considering differences in the practices of the various railroads which influence costs, as pointed out in the 1929 and 1941 Proceedings.

ing up to
ngs

F. Brown,
lner, W. R.
ury, W. D.

intention,
rossties.
recommends

to read as

3, 7 inches

ended:
e of 8-foot

the 8-foot

Campbell,
kson, Roy

the subject

ublished in

mittee 3—
e splitting
as consid-
roads. The
procedures
ers to the
marized as

TABLE A

CROSS TIES LAID IN REPLACEMENT - CLASS I STEAM ROADS, UNITED STATES AND LARGE CANADIAN ROADS

Calendar year ended December 31, 1940

Road	New wooden tie untreated (U)		New wooden tie treated (T)		Ties other than wood(S) and secondhand reapplied ties	Total ties applied	Miles of maintained tracks (item 24)	Estimated total cross ties in all maintained tracks (item 25)	Total equated gross ton-miles ± (thousands)
	Number	Average cost	Number	Average cost					
1	2	3	4	5	6	7	8	9	10
NEW ENGLAND REGION:									
Bangor & Aroostook	145 059	$0.65	-	-	-	145 059	829.81	2 375 947	1 221 294
Boston & Maine	42 695	0.89	256 291	$1.66	-	298 986	3 075.58	9 000 000	13 505 912
Canadian Nat.Lines in New Eng.	9 596	0.65	28 154	1.23	-	37 750	248.77	763 686	608 120
Canadian Pacific (lines in Me.)	328	0.52	11 524	1.22	-	11 852	212.40	653 261	1 495 436
Canadian Pacific (lines in Vt.)	616	0.60	7 322	1.12	-	7 938	127.78	382 511	575 538
Central Vermont	826	1.03	41 048	1.23	-	41 874	496.27	1 424 211	2 354 231
Maine Central	125 318	0.74	73 922	1.84	-	199 440	1 235.87	3 747 800	3 331 382
New York Connecting	-	-	9 768	1.78	-	9 768	25.90	81 641	363 770
New York,New Haven & Hartford	-	-	207 319	1.02	-	207 319	3 942.81	12 057 503	20 593 148
Rutland	-	-	22 923	1.25	*212	23 135	499.85	1 550 900	1 556 733
Total	324 638	0.72	658 271	1.41	212	983 121	10 695.04	32 037 460	45 605 566
GREAT LAKES REGION:									
Ann Arbor	-	-	36 244	1.47	-	36 244	403.74	1 220 161	1 538 527
Cambria & Indiana	1 098	0.96	19 346	1.91	-	20 444	58.45	159 000	159 354
Delaware & Hudson	799	1.22	165 128	1.87	(S) 31	165 958	1 435.27	4 385 272	9 509 063
Delaware,Lackawanna & Western	-	-	125 863	1.64	*19 096	144 959	2 314.78	6 712 862	16 340 410
Detroit & Mackinac	20 294	0.48	13 538	0.78	-	33 832	293.45	879 801	233 950
Detroit & Toledo Shore Line	-	-	18 060	1.79	* 21	18 081	151.61	456 583	768 446
Erie (Incl.Chgo.& Erie)	339	0.48	400 090	1.41	-	400 429	4 809.75	14 085 123	34 570 427
Grand Trunk Western	-	-	302 150	1.56	-	302 150	1 940.29	6 133 908	8 500 413
Lehigh & Hudson River	-	-	8 515	2.21	-	8 515	115.40	310 000	637 466
Lehigh & New England	-	-	16 526	1.70	-	16 526	266.94	805 128	908 325
Lehigh Valley	-	-	154 234	1.73	-	154 234	2 684.37	7 964 429	15 591 588
Monongahela	-	-	43 422	1.64	-	43 422	241.63	704 545	1 020 032
Montour	100	1.10	6 776	2.14	*1 160	8 036	71.41	205 676	338 323
New York Central	376	0.79	2 127 371	1.50	*18 911	2 146 658	21 573.76	67 768 627	156 354 955
New York,Chicago & St.Louis	-	-	297 352	1.43	-	297 352	2 521.86	7 943 853	18 824 065
New York,Ontario & Western	-	-	-	-	*35 172	35 172	367.83	2 484 552	2 133 352
New York,Susquehanna & Western	-	-	15 700	0.61	-	15 700	227.94	642 535	408 997
Pere Marquette	-	-	488 705	1.61	-	488 705	2 801.29	8 475 870	11 224 231
Pittsburgh & Lake Erie	96	0.97	85 021	1.85	-	85 117	317.62	2 748 914	4 736 866
Pittsburg & Shawmut	1 335	1.01	16 148	1.86	*274	17 757	123.32	344 242	256 259
Pittsburgh & West Virginia	729	0.96	57 066	2.04	*524	58 319	186.28	564 420	1 006 731
Pittsburg,Shawmut & Northern	34 084	0.99	1 577	1.26	-	35 661	220.44	647 670	326 744
Wabash	-	-	463 915	1.54	-	463 915	3 175.25	9 888 454	20 288 858
Total	73 250	0.85	4 862 747	1.55	75 189	5 011 186	47 402.48	145 551 625	305 677 382
CENTRAL EASTERN REGION:									
Akron,Canton & Youngstown	1 821	1.19	47 913	1.39	*1 428	51 162	212.85	636 866	535 015
Baltimore & Ohio	3 256	0.79	1 189 585	1.46	-	1 192 841	10 573.43	30 088 418	69 831 711
Bessemer & Lake Erie	-	-	72 344	2.18	(S) 85	72 429	489.60	1 514 216	4 643 587
Central R.R.of New Jersey	-	-	132 827	1.72	-	132 827	1 481.71	4 164 356	8 692 946
Chicago & Eastern Illinois	-	-	136 764	1.19	-	136 764	1 462.42	4 236 915	6 270 641
Chicago & Illinois Midland	-	-	9 646	1.05	-	9 646	165.07	508 168	1 175 134
Chicago,Indple.& Louisville	1 303	0.72	76 059	1.16	*800	78 162	793.00	2 444 876	3 472 823
Detroit,Toledo & Ironton	1 246	0.55	48 575	1.39	-	49 821	610.14	1 757 203	1 842 942
Elgin,Joliet & Eastern	-	-	158 672	1.56	*1 496	160 168	871.20	2 691 942	3 211 325
Illinois Terminal	2 483	0.86	64 892	1.27	*2 021	66 336	633.40	1 900 200	993 411
Long Island	-	-	48 797	1.68	-	48 797	803.80	2 305 066	3 805 025
Missouri-Illinois	64 874	0.68	604	1.23	-	65 478	240.09	747 280	335 428
Pennsylvania	362	0.84	1 786 858	1.62	± 2 150	1 789 370	21 281.42	59 586 484	175 749 919
Penna.-Reading Seashore Lines	-	-	84 168	1.87	-	84 168	663.19	1 734 481	1 801 155
Reading Co.	-	-	173 236	1.82	-	173 236	3 008.55	8 318 489	10 601 200
Staten Island Rapid Transit	-	-	7 746	0.59	-	7 746	80.71	221 357	139 958
Western Maryland	37 290	0.96	171 472	1.60	-	208 762	1 169.03	3 334 027	6 278 966
Wheeling & Lake Erie	-	-	144 966	1.46	-	144 966	844.45	2 530 271	4 165 065
Total	112 635	0.79	4 372 064	1.56	9 980	4 494 679	45 384.06	128 720 615	309 546 298
POCAHONTAS REGION:									
Chesapeake & Ohio	-	-	385 370	1.28	(S) 425	385 795	5 092.87	15 674 144	52 891 461
Norfolk & Western	-	-	173 758	1.33	*7 160	180 918	4 253.90	13 187 090	41 427 211
Richmond,Fred.& Potomac	-	-	132 481	1.70	*485	132 966	371.44	1 061 200	4 143 511
Virginian	-	-	124 617	1.36	*1 152	125 769	874.49	2 691 563	9 059 488
Total	-	-	816 226	1.37	9 222	825 448	10 592.70	32 613 997	107 521 671
SOUTHERN REGION:									
Alabama Great Southern	1 364	1.37	46 064	1.79	-	47 428	547.75	1 706 264	3 376 616
Atlanta & West Point	21 508	1.23	241	0.89	-	21 749	141.73	433 777	706 924
Western Ry.of Alabama	25 366	1.23	2 319	1.49	-	27 685	182.08	552 898	756 543
Atlanta,Birmingham & Coast	55 412	0.78	67 042	1.15	-	122 454	793.06	2 295 375	1 905 927
Atlantic Coast Line	606 228	0.82	210 983	1.20	-	817 211	6 824.76	19 869 177	24 935 271
Central of Georgia	3 275	0.97	360 089	1.02	-	363 364	2 330.30	6 857 000	7 769 986
Charleston & Western Carolina	58 778	1.09	-	-	-	58 778	427.65	1 234 935	898 754
Cincinnati,New Orleans & Tex.Pac.	140	0.50	49 818	1.78	-	49 958	772.43	2 408 029	7 952 618
Clinchfield	55 335	0.73	41 326	1.40	-	96 661	392.99	1 194 689	3 063 871
Columbus & Greenville	8 429	0.61	17 272	1.39	-	25 701	204.60	648 173	334 582
Florida East Coast	243 546	0.99	23 825	1.69	-	267 371	1 343.67	3 856 616	5 495 099
Georgia	64 122	1.08	2 748	2.02	-	66 870	433.02	1 326 801	1 596 899
Georgia & Florida	91 550	0.63	-	-	-	91 550	452.11	1 220 697	474 489
Georgia,Southern & Florida	58 360	1.08	-	-	-	58 360	468.85	1 474 868	1 609 163
Gulf & San Saba	-	-	69 245	1.07	-	69 245	310.30	936 678	498 840
Gulf,Mobile & Ohio	177 741	0.65	477 933	1.07	*689	656 363	2 098.62	6 085 722	7 049 756
Illinois Central	22 141	0.89	1 399 352	1.11	*17	1 421 510	7 701.99	23 448 650	43 617 423
Yazoo & Miss.Valley	129 467	0.76	277 444	1.11	-	406 911	2 098.81	6 415 813	5 904 949
Louisville & Nashville	21 389	1.07	821 739	1.44	-	843 128	6 874.15	19 666 473	41 121 333
Mississippi Central	1 286	0.46	46 401	1.10	-	47 687	174.23	549 963	220 914
Nashville,Chatt.& St.Louis	-	-	160 514	1.41	-	160 514	1 518.69	4 159 692	6 380 527
New Orleans & Northeastern	-	-	25 709	1.73	-	25 709	281.27	858 239	1 416 526
Norfolk Southern	288 179	0.62	-	-	-	288 179	847.80	2 340 780	1 444 753
Seaboard Air Line	321 049	0.95	669 134	1.19	-	990 183	5 358.64	16 230 467	21 655 188
Southern Ry.	504 237	1.21	1 107 166	1.62	-	1 611 403	8 653.46	26 992 190	44 034 896
Tennessee Central	74 696	0.75	9 774	1.31	-	84 470	337.51	1 021 990	789 165
Total	2 833 598	0.90	5 886 338	1.29	706	8 720 642	51 570.46	154 405 956	235 628 012

ing up to
ngs

F. Brown,
lner, W. R.
ury, W. D.

intention,
rossties.
recommends

to read as

3, 7 inches

ended:
e of 8-foot

the 8-foot

Campbell,
kson, Roy

the subject

ublished in

mittee 3—
e splitting
as consid-
roads. The
procedures
ers to the
marized as

TABLE A

GROSS TIES LAID IN REPLACEMENT - CLASS I STEAM ROADS, UNITED STATES AND LARGE CANADIAN ROADS

Calendar year ended December 31, 1940

Road	New wooden ties untreated (1)		New wooden ties treated (2)		Ties other than wood(3) and secondhand reapplied tie.	Total ties applied	Miles of maintained tracks (item 24)	Estimated total cross ties in all maintained tracks (item 25)	Total equated gross ton-miles a (thousands)
	Number	Average cost	Number	Average cost					
1	2	3	4	5	6	7	8	9	
NORTHWESTERN REGION:									
Chicago & North Western	58 874	$0.56	1 420 917	$1.07	-	1 479 791	11 807.65	35 202 871	38 095 384
Chicago Great Western	144 931	0.98	164 008	1.47	-	308 939	1 892.85	5 607 099	9 078 806
Chicago,Milwaukee,St.Paul & Pac.	449 217	0.56	1 937 766	1.32	-	2 386 983	13 739.78	42 353 330	48 861 028
Chicago,St.Paul,Minpls.& Omaha	32 512	0.59	343 037	1.27	-	375 549	2 211.20	6 551 661	7 231 213
Duluth,Missabe & Iron Range	21 050	0.76	91 533	1.64	-	112 583	1 106.00	3 275 870	4 894 662
Duluth,South Shore & Atlantic	98 987	0.60	6 802	1.24	-	105 789	517.75	1 472 142	815 964
Duluth,Winnipeg & Pacific	56 217	0.56	10 485	1.62	-	66 702	209.78	611 382	566 679
Great Northern	24 940	0.49	1 388 367	1.31	*49 951	1 463 258	7 881.45	30 547 078	40 028 849
Green Bay & Western	98 077	0.88	494	1.31	-	98 571	283.22	815 674	525 542
Lake Superior & Ishpeming	39 278	0.62	3 326	1.31	-	42 604	232.39	697 170	220 161
Minneapolis & St.Louis	255 544	0.74	94 348	1.36	-	349 892	1 556.09	4 730 126	5 584 402
Minneapolis,St.Paul & S.S.Marie	403 870	0.62	278 001	1.16	-	681 871	4 331.36	14 532 048	11 777 525
Northern Pacific	17 900	0.57	1 175 473	1.18	(S) 24	1 193 397	8 985.43	26 109 283	30 812 730
Spokane International	58 755	0.46	58	1.68	-	58 813	179.25	505 363	248 486
Spokane,Portland & Seattle	38 535	0.51	250 276	1.26	-	288 811	1 092.54	3 161 193	3 836 388
Total	1 798 687	0.65	7 164 891	1.25	49 975	9 013 553	58 706.74	176 197 710	200 096 914
CENTRAL WESTERN REGION:									
Alton R.R.	237 924	1.08	130 244	1.76	*14 179	382 347	1 507.24	4 552 430	7 049 702
Atchison,Topeka & Santa Fe	-	-	1 755 435	1.25	-	1 755 435	19 325.62	58 621 908	87 262 768
Chicago,Burlington & Quincy	-	-	1 671 856	1.28	*259 214	1 931 070	12 292.87	37 963 648	47 348 579
Chgo.,R.I.& Pac. (Inc.CRI&G)	-	-	1 064 945	0.96	-	1 064 945	9 790.36	29 203 236	38 686 630
Colorado & Southern	4 830	0.46	84 430	1.23	*13 137	102 397	887.55	2 724 020	2 838 422
Denver & Rio Grande Western	10 674	0.47	170 124	1.09	*44 392	225 190	3 271.97	10 232 946	12 577 611
Denver & Salt Lake	-	-	41 218	1.29	-	41 218	315.37	963 140	818 218
Fort Worth & Denver City	-	-	83 564	1.13	*4 402	87 966	750.06	2 621 655	2 750 658
Nevada Northern	36 497	0.87	-	-	-	36 497	191.02	548 220	139 794
Northwestern Pacific	78 794	0.7	488	1.31	-	79 282	458.75	1 339 555	926 615
Southern Pacific	167 842	0.71	1 075 972	1.19	*456	1 244 272	12 242.33	37 165 442	80 088 033
Toledo,Peoria & Western	-	-	60 150	1.37	-	60 150	276.84	876 396	767 504
Union Pacific	55 448	0.61	2 043 880	1.13	-	2 099 328	13 147.87	37 127 509	83 101 319
Utah	118	0.70	5 976	2.21	*886	6 094	724.21	205 076	229 356
Western Pacific	189 253	0.79	328 617	1.25	-	517 870	1 469.79	4 368 843	9 220 398
Total	781 580	0.84	8 518 013	1.19	336 468	9 636 061	76 208.65	228 649 524	375 766 207
SOUTHWESTERN REGION:									
Burlington-Rock Island	-	-	19 216	0.98	-	19 216	208.16	651 541	400 162
Gulf Coast Lines:									
Beaumont,Sour Lake & Western	-	-	15 916	1.14	-	15 916	139.79	416 200	894 158
New Orleans,Texas & Mexico	45	0.60	29 146	1.14	-	29 191	225.02	688 400	763 042
St.Louis,Brownsville & Mexico	-	-	98 198	1.08	-	98 198	747.45	2 267 700	2 406 394
San Antonio,Uvalde & Gulf	-	-	41 825	1.08	-	41 825	359.80	1 037 400	483 783
International-Great Northern	-	-	177 694	1.02	-	177 694	1 474.44	4 422 300	5 277 608
Kansas City Southern	6	0.67	167 184	1.05	-	167 190	1 257.93	3 985 997	5 536 180
Kansas,Oklahoma & Gulf	-	-	18 762	0.98	-	18 762	352.03	1 042 000	753 304
Louisiana & Arkansas	26 982	0.52	153 231	0.94	-	180 213	910.30	2 956 203	2 643 531
Midland Valley	113	0.19	26 473	1.03	-	26 586	380.77	1 128 980	373 576
Missouri & Arkansas	110 401	0.48	-	-	-	110 401	358.32	1 116 501	429 546
Missouri-Kansas-Texas Lines	31 319	0.70	276 565	0.99	-	307 884	4 067.52	12 787 400	13 445 921
Missouri Pacific	114 395	0.60	1 386 630	1.07	-	1 501 025	8 967.02	27 672 388	42 470 052
Oklahoma City-Ada-Atoka	9 903	0.46	7 311	0.25	-	17 214	141.36	406 980	241 833
St.Louis-San Francisco	35 214	0.63	731 344	1.05	-	766 558	6 339.58	20 140 139	20 890 494
St.Louis,San Francisco Texas	1 578	0.63	26 250	1.04	-	27 828	153.15	479 006	425 123
St.Louis Southwestern Lines	-	-	309 213	1.16	*609	309 822	1 865.27	5 909 138	8 456 446
Texas & New Orleans	229	0.27	804 433	0.88	-	804 662	5 637.44	15 349 312	19 253 586
Texas & Pacific	-	-	272 433	1.02	-	272 433	2 427.31	7 088 900	11 915 052
Texas Mexican	3 332	0.25	35 394	1.12	-	38 726	203.81	645 670	127 902
Total	333 517	0.56	4 597 818	1.02	609	4 931 944	36 279.67	110 192 235	137 010 693
Grand Total - United States	6 257 905	0.79	36 876 368	1.29	485 361	43 616 634	336 839.80	1 008 369 122	1 116 852 708
CANADIAN ROADS:									
Canadian National	4 074 850	0.61	1 683 627	1.20	-	5 758 287	26 862	76 758 859	78 298 584 926
Canadian Pacific	1 608 284	0.54	1 455 140	1.19	-	3 064 394	21 274	60 857 865	66 554 685 459
Temiskaming & Northern Ontario	150 372	0.65	-	-	-	150 372	575	1 634 150	1 405 912 829

* Secondhand ties.

t Tunnel ties.

a Gross ton-miles of cars and contents, plus two times gross ton-miles of locomotives and tenders in freight service, plus three times gross ton-miles of locomotives and tenders in passenger service.

Note: "Average cost", as shown in columns 3 and 5, represent storekeepers' average cost of ties charged out and used. They are not the actual costs or the prices paid for ties purchased during the period.

Note: Compiled from annual reports of Class I railways to the Interstate Commerce Commission.

Compiled by
Association of American Railroads
Bureau of Railway Economics
Washington, D.C.

ing up to
.ngs

F. Brown,
lner, W. R.
ury, W. D.

e intention,
rossties.
recommends

to read as

3, 7 inches

ended:
e of 8-foot

the 8-foot

Campbell,
kson, Roy

the subject

ublished in

mittee 3—
e splitting
as consid-
roads. The
procedures
ers to the
marized as

TABLE 8

NEW WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES AND CANADA

Calendar year ended December 31, 1940

Note: All figures are exclusive of bridge & switch ties

Road	Miles of maintained track occupied by cross ties (Col.8-Table A)	Average number of cross ties per mile of maintained track	Total number of new wooden cross ties laid in replacement 1940	Number of new wooden cross ties laid in replacement per mile of maintained track	Weighted average cost per new wooden cross tie	Cost of new wooden cross tie renewals per mile of maintained track	Per cent new wooden cross tie renewals to all ties in tracks	Equated gross ton-miles per mile of maintained track	Cost of new wooden cross tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
NEW ENGLAND REGION:									(cents)
Bangor & Aroostook	829.81	2 863	145 059	175	$0.65	$113	6.1	1 471 775	7.68
Boston & Maine	3 075.58	2 926	298 986	97	1.55	150	3.3	4 391 338	3.42
Canadian Nat.Lines in New Eng.	248.77	3 070	37 750	152	1.08	164	4.9	2 444 507	6.73
Canadian Pacific (lines in Me.)	212.40	3 076	11 852	56	1.20	67	1.8	7 040 659	0.95
Canadian Pacific (lines in Vt.)	127.78	2 994	7 938	62	1.08	67	2.1	4 504 132	1.49
Central Vermont	496.27	2 970	41 574	84	1.23	104	2.9	4 743 855	2.19
Maine Central	1 235.87	3 033	199 440	161	1.15	185	5.3	2 695 576	6.87
New York Connecting	25.90	3 152	9 768	377	1.78	672	12.0	14 045 174	4.79
New York,New Haven & Hartford	3 942.81	3 058	207 319	53	1.02	54	1.7	5 222 362	1.03
Rutland	493.85	3 103	22 923	46	1.25	57	1.5	3 114 400	1.85
Total	10 695.04	2 996	932 909	92	1.18	108	3.1	4 264 179	2.54
GREAT LAKES REGION:									
Ann Arbor	405.74	3 022	36 244	90	1.47	132	3.0	3 810 688	3.46
Camorie & Indiana	58.45	2 720	20 444	350	1.86	651	12.9	2 726 330	23.89
Delaware & Hudson	1 435.27	3 055	165 927	116	1.86	215	3.8	6 625 278	3.25
Delaware,Lackawanna & Western	2 314.78	2 900	125 863	54	1.64	89	1.9	7 059 163	1.27
Detroit & Mackinac	293.45	2 938	33 832	115	0.60	69	3.8	797 240	8.68
Detroit & Toledo Shore Line	151.61	3 012	18 060	119	1.79	213	4.0	5 068 571	4.21
Erie (Incl.Chgo.& Erie)	4 809.75	2 928	400 429	83	1.41	118	2.8	7 187 573	1.64
Grand Trunk Western	1 940.29	3 161	302 150	156	1.56	243	4.9	4 381 001	5.54
Lehigh & Hudson River	115.40	2 685	8 515	74	2.21	163	2.7	5 523 960	2.95
Lehigh & New England	260.94	3 016	16 526	62	1.70	105	2.1	3 402 731	3.10
Lehigh Valley	2 [illegible]4.37	2 967	154 234	57	1.73	100	1.9	5 808 286	1.72
Monongahela	241.63	2 916	43 422	180	1.64	294	6.2	4 221 463	6.97
Montour	71.41	2 880	6 876	96	2.13	205	3.3	4 737 754	4.32
New York Central	21 573.76	3 141	2 127 747	99	1.50	148	3.1	7 247 466	2.05
New York,Chicago & St.Louis	2 924.86	3 150	297 352	118	1.45	172	3.7	7 464 358	2.30
New York,Ontario & Western	849.83	2 864	-	-	-	-	-	2 458 827	-
New York,Susquehanna & Western	227.94	2 907	15 700	69	0.61	42	2.4	1 794 319	2.35
Pere Marquette	2 801.29	3 026	488 705	174	1.61	281	5.8	4 006 808	7.00
Pittsburgh & Lake Erie	917.62	2 996	85 117	93	1.85	172	3.1	5 162 122	3.33
Pittsburg & Shawmut	123.32	2 791	31 483	255	1.44	369	9.1	2 071 000	17.75
Pittsburgh & West Virginia	186.28	3 030	37 795	210	2.02	428	10.2	5 404 397	11.62
Pittsburg,Shawmut & Northern	220.44	2 938	35 661	162	1.00	162	3.5	1 482 236	10.94
Wabash	3 175.25	3 114	463 915	146	1.54	225	4.7	6 389 688	3.53
Total	47 402.48	3 071	4 935 937	104	1.54	160	3.4	6 448 553	2.48
CENTRAL EASTERN REGION:									
Akron,Canton & Youngstown	212.85	2 992	49 734	234	1.38	323	7.8	2 513 578	12.85
Baltimore & Ohio	10 573.43	2 846	1 192 841	113	1.46	165	4.0	6 604 452	2.49
Bessemer & Lake Erie	489.60	3 093	72 344	148	2.18	322	4.8	9 484 451	3.40
Central R.R.of New Jersey	1 481.71	2 811	132 827	90	1.72	154	3.2	5 866 834	2.62
Chicago & Eastern Illinois	1 462.42	2 897	156 764	107	1.19	128	3.7	4 287 831	2.98
Chicago & Illinois Midland	165.07	3 079	9 646	58	1.65	97	1.9	7 119 307	1.36
Chicago,Indpls.& Louisville	793.00	3 083	77 302	98	1.15	112	3.2	4 379 334	2.56
Detroit,Toledo & Ironton	610.14	2 800	49 521	81	1.37	112	2.8	3 020 495	3.67
Elgin,Joliet & Eastern	871.20	3 090	158 672	182	1.56	284	7.9	3 680 094	7.71
Illinois Terminal	633.40	3 000	64 315	102	1.25	127	3.4	1 568 379	8.10
Long Island	805.80	2 868	45 797	61	1.68	102	2.1	4 733 796	2.16
Missouri-Illinois	240.09	3 112	65 475	273	0.69	187	8.8	1 397 093	13.27
Pennsylvania	21 281.42	2 800	1 787 220	84	1.62	136	3.0	8 298 374	1.65
Penna.-Reading Seashore Lines	663.19	2 615	84 168	127	1.87	237	4.9	2 715 896	8.74
Reading Co.	3 008.55	2 765	173 236	58	1.82	105	2.1	5 518 007	1.90
Staten Island Rapid Transit	80.71	2 743	7 746	96	0.59	56	3.5	1 734 085	3.26
Western Maryland	1 169.03	2 852	203 762	179	1.48	265	6.3	5 371 091	4.93
Wheeling & Lake Erie	844.45	2 996	144 966	172	1.46	251	5.7	4 932 281	5.10
Total	45 384.06	2 836	4 484 639	99	1.54	152	3.5	6 820 594	2.23
POCAHONTAS REGION:									
Chesapeake & Ohio	5 092.37	3 078	385 370	76	1.28	97	2.5	10 385 594	0.93
Norfolk & Western	4 253.90	3 100	173 758	41	1.33	55	1.3	9 738 642	0.56
Richmond,Fred.& Potomac	371.44	2 857	132 481	357	1.70	605	12.5	11 155 263	5.42
Virginian	874.49	3 077	124 617	143	1.36	194	4.6	10 157 739	1.87
Total	10 592.70	3 079	816 226	77	1.37	106	2.5	10 150 544	1.04
SOUTHERN REGION:									
Alabama Great Southern	547.75	3 115	47 428	87	1.78	154	2.8	6 164 520	2.50
Atlanta & West Point	141.73	3 061	21 749	153	1.23	188	5.0	4 987 522	3.77
Western Ry.of Alabama	182.08	3 037	27 885	153	1.26	193	5.0	4 155 003	4.63
Atlanta,Birmingham & Coast	793.06	2 894	122 454	154	0.98	152	5.3	2 401 427	6.32
Atlantic Coast Line	6 824.76	2 911	817 211	120	0.92	110	4.1	3 653 648	3.01
Central of Georgia	2 330.30	2 943	363 364	156	1.01	158	5.3	3 342 911	4.73
Charleston & Western Carolina	427.65	2 888	58 778	137	1.09	149	4.8	2 101 611	7.11
Cincinnati,New Orleans & Tex.Pac.	772.43	3 117	49 958	65	1.78	115	2.1	10 295 584	1.12
Clinchfield	392.99	3 040	96 661	246	1.02	250	8.1	7 796 308	3.21
Columbus & Greenville	204.60	3 158	25 701	126	1.15	145	4.0	1 635 298	8.84
Florida East Coast	1 343.67	2 870	267 371	199	1.05	209	6.9	4 087 387	5.11
Georgia	433.01	3 064	66 870	154	1.12	173	5.0	3 687 903	4.69
Georgia & Florida	452.11	2 700	91 550	202	0.63	127	7.5	1 049 499	12.07
Georgia,Southern & Florida	468.35	3 146	58 360	124	1.08	134	4.0	3 432 149	3.91
Gulf & Ship Island	310.30	3 083	69 245	223	1.07	238	7.2	1 607 006	14.79
Gulf,Mobile & Ohio	2 098.62	3 186	655 674	312	0.96	300	9.8	3 359 234	8.93
Illinois Central	7 701.99	3 044	1 421 493	185	1.11	205	6.1	5 663 137	3.61
Yazoo & Miss.Valley	2 098.81	3 037	406 911	194	0.99	193	6.3	2 813 475	6.86
Louisville & Nashville	6 874.15	2 864	843 128	123	1.43	176	4.3	5 382 024	3.94
Mississippi Central	174.23	3 157	47 687	274	1.08	296	8.7	1 287 945	23.37
Nashville,Chatt.& St.Louis	1 518.69	2 739	160 514	106	1.41	149	3.9	4 201 336	3.56
New Orleans & Northeastern	281.27	3 051	25 709	91	1.73	158	3.0	5 036 179	3.14
Norfolk Southern	847.80	2 761	288 179	340	0.62	212	12.3	1 704 120	12.43
Seaboard Air Line	5 358.64	3 029	990 183	185	1.12	206	6.1	4 041 172	5.10
Southern Ry.	8 653.46	3 119	1 611 403	186	1.50	279	6.0	5 158 040	5.40
Tennessee Central	337.51	3 028	84 470	250	0.82	204	8.3	2 335 197	8.73
Total	51 570.46	2 994	8 719 936	169	1.16	196	5.6	4 569 050	4.30

ing up to
.ngs

F. Brown,
lner, W. R.
ury, W. D.

intention,
rossties.
recommends

to read as

3, 7 inches

ended:
e of 8-foot

the 8-foot

Campbell,
kson, Roy

the subject

ublished in

.mittee 3—
ne splitting
as consid-
roads. The
procedures
ers to the
marized as

TABLE B

NEW WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES AND CANADA

Calendar year ended December 31, 1940

Note: All figures are exclusive of [illegible]

Road	Miles of maintained track occupied by cross ties (Col.8-Table A)	Average number of cross ties per mile of maintained track	Total number of new wooden cross ties laid in replacement 1940	Number of new wooden cross ties laid in replacement per mile of maintained track	Weighted average cost per new wooden cross tie	Cost of new wooden cross tie renewals per mile of maintained track	Per cent new wooden cross tie renewals to all ties in tracks	Equated gross ton-miles per mile of maintained track	Cost of new wooden cross tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	(cents)
NORTHWESTERN REGION:									
Chicago & North Western	11 887.65	2 961	1 479 791	124	$1.05	$131	4.2	3 204 619	4.08
Chicago Great Western	1 892.85	2 962	308 939	163	1.24	202	5.5	4 796 368	4.22
Chicago, Milwaukee, St.Paul & Pac.	13 739.78	3 083	2 386 983	174	1.18	205	5.6	3 556 173	5.76
Chicago, St.Paul, Minpls.& Omaha	2 211.20	2 963	375 549	170	1.21	206	5.7	3 271 171	6.29
Duluth, Missabe & Iron Range	1 106.00	2 980	112 581	102	1.47	150	3.4	4 435 553	3.39
Duluth, South Shore & Atlantic	517.75	2 843	105 789	204	0.64	130	7.2	1 570 380	8.20
Duluth, Winnipeg & Pacific	209.78	2 927	66 702	318	0.72	230	10.9	2 701 301	8.51
Great Northern	9 881.45	3 091	1 413 307	143	1.30	185	4.6	4 050 908	4.57
Green Bay & Western	283.22	2 850	98 571	348	0.89	308	12.1	1 855 596	16.62
Lake Superior & Ishpeming	232.39	3 000	42 604	183	0.69	127	6.1	947 377	13.43
Minneapolis & St.Louie	1 556.09	3 040	349 892	225	0.91	204	7.4	1 982 149	10.28
Minneapolis, St.Paul & S.S.Marie	4 931.36	2 947	681 871	138	0.84	117	4.7	2 388 291	4.88
Northern Pacific	8 985.43	2 906	1 193 373	133	1.18	156	4.6	3 431 414	4.55
Spokane International	179.25	2 836	58 813	328	0.46	150	11.6	1 386 454	10.81
Spokane, Portland & Seattle	1 092.54	2 893	288 811	264	1.16	306	9.1	3 511 429	8.71
Total	58 706.74	3 001	8 963 578	153	1.13	172	5.1	3 408 415	5.04
CENTRAL WESTERN REGION:									
Alton	1 507.24	3 020	368 168	244	1.32	323	8.1	4 677 226	6.91
Atchison, Topeka & Santa Fe	19 325.62	3 037	1 755 435	91	1.25	113	3.0	4 515 393	2.51
Chicago, Burlington & Quincy	12 295.87	3 088	1 673 856	136	1.28	175	4.4	3 850 771	4.54
Chgo., R.I.& Pac. (Inc.CRI&G)	9 790.36	2 983	1 064 945	109	0.96	104	3.6	3 945 374	2.63
Colorado & Southern	887.55	3 009	89 260	101	1.19	120	3.3	3 220 576	3.72
Denver & Rio Grande Western	3 277.97	3 122	180 798	55	1.05	58	1.8	3 837 012	1.51
Denver & Salt Lake	315.37	3 054	41 218	131	1.29	169	4.3	2 574 473	6.56
Fort Worth & Denver City	950.06	2 823	83 564	88	1.13	10	3.1	2 895 247	3.45
Nevada Northern	191.02	2 870	36 497	191	0.87	167	6.7	8 06 530	12.93
Northwestern Pacific	458.75	2 920	79 282	173	0.75	130	5.9	2 049 869	6.44
Southern Pacific	12 242.33	3 036	1 243 814	102	1.13	115	3.3	6 541 895	1.75
Toledo, Peoria & Western	276.64	3 168	60 130	217	1.37	298	6.9	2 774 378	10.75
Union Pacific	13 147.87	2 824	2 099 328	160	1.12	178	5.7	6 472 032	2.75
Utah	74.21	2 843	5 408	73	2.12	159	2.6	3 176 436	5.01
Western Pacific	1 467.75	2 972	517 870	352	1.14	402	11.9	6 200 077	6.43
Total	76 200.[illegible]	3 000	9 299 593	122	1.16	142	4.1	4 930 755	2.88
SOUTHWESTERN REGION:									
Burlington-Rock Island	208.16	3 130	19 216	92	0.98	91	2.9	1 922 377	4.72
Gulf Coast Lines:									
Beaumont, Sour Lake & Western	139.79	2 977	15 916	114	1.14	130	3.8	6 296 438	2.03
New Orleans, Texas & Mexico	225.02	3 039	29 191	130	1.14	148	4.2	3 390 936	4.37
St.Louis, Brownsville & Mexico	749.45	3 026	98 198	131	1.08	142	4.3	3 210 880	4.41
San Antonio, Uvalde & Gulf	359.80	2 883	41 825	116	1.08	125	4.0	3 144 589	3.96
International-Great Northern	1 474.44	2 999	177 694	121	1.02	123	4.0	3 577 328	3.43
Kansas City Southern	1 257.93	3 169	157 190	133	1.05	140	4.2	4 421 324	3.17
Kansas, Oklahoma & Gulf	352.01	2 960	18 762	53	0.98	52	1.8	2 139 886	2.44
Louisiana & Arkansas	910.90	3 245	180 213	198	0.87	173	6.1	2 902 109	5.96
Midland Valley	380.77	2 961	26 386	70	1.03	72	2.4	981 137	7.34
Missouri & Arkansas	3[illegible].32	3 118	110 401	307	0.48	147	9.9	1 198 778	12.[illegible]
Missouri-Kansas-Texas Lines	4 067.52	3 144	307 834	76	0.96	73	2.4	3 305 680	2.21
Missouri Pacific	8 967.02	3 086	1 501 025	167	1.03	173	5.4	4 736 250	3.65
Oklahoma City-Ada-Atoka	141.36	2 879	17 214	122	0.37	45	4.2	437 415	10.31
St.Louis-San Francisco	6 399.[illegible]8	3 147	[illegible]66 [illegible]58	120	1.03	123	3.8	2 [illegible] 324	3.[illegible]
St.Louis, San Francisco & Texas	153.15	3 1[illegible]	27 828	182	1.02	185	5.8	2 795 447	6.61
St.Louis Southwestern Lines	1 805.27	3 103	307 213	166	1.16	193	5.2	4 331 931	4.46
Texas & New Orleans	5 637.44	2 723	804 602	143	0.88	125	5.2	3 415 307	3.67
Texas & Pacific	2 427.91	2 920	272 433	112	1.02	114	3.8	4 907 534	2.33
Texas Mexican	203.81	3 188	39 325	193	1.05	203	6.1	627 555	32.29
Total	36 279.67	3 037	4 931 335	136	0.99	135	4.5	3 776 514	3.57
Grand Total - United States	336 835.80	2 994	43 134 273	128	1.22	156	4.3	3 996 941	3.97
CANADIAN ROADS:									
Canadian National	26 862	2 952	5 758 287	214	0.81	173	7.3	2 914 838	5.94
Canadian Pacific	21 274	2 850	3 064 394	144	0.88	112	5.1	3 054 440	4.02
Temiskaming & Northern Ontario	574	2 900	157 800	287	0.68	174	8.8	2 494 868	6.90

Col.3 derived by dividing Col.9 Table A, by Col.8 of same table.
Col.4 is total of cols. 2 and 4 of Table A.
Col.5 derived by dividing total of Cols.2 and 4 Table A, by Col.3 of same table.
Col.6 is weighted average of costs shown in Cols.3 and 5 of Table A.
Col.7 is total cost of ties shown in Cols.2 and 4 Table A, divided by Col.8 of same table.
Col.8 is ratio of total new ties (Cols.2 and 4 Table A) to Col.9 of same table.
Col.9 derived by dividing Col.10 Table A, by Col.8 of same table.
Col.10 is total cost of ties shown in Cols.2 and 4 Table A, divided by Col.10 of same table.

Source: Compiled from annual reports of Class I railways to the Interstate Commerce Commission.

Compiled by
Association of American Railroads
Bureau of Railway Economics
Washington, D.C.

ing up to
.ngs

F. Brown,
lner, W. R.
ury, W. D.

intention,
rossties.
recommends

to read as

3, 7 inches

ended:
e of 8-foot

the 8-foot

Campbell,
kson, Roy

the subject

ublished in

mittee 3—
e splitting
as consid-
roads. The
procedures
ers to the
marized as

TABLE B

NEW WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES AND CANADA

Calendar year ended December 31, 1940

Note: All figures are exclusive of [illegible]

Road	Miles of maintained track occupied by cross ties (Col.8-Table A)	Average number of cross ties per mile of maintained track	Total number of new wooden cross ties laid in replacement 1940	Number of new wooden cross ties laid in replacement per mile of maintained track	Weighted average cost per new wooden cross tie	Cost of new wooden cross tie renewals per mile of maintained track	Per cent new wooden cross tie renewals to all ties in tracks	Equated gross ton-miles per mile of maintained track	Cost of new wooden cross tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	[illegible]
NORTHWESTERN REGION:									(cents)
Chicago & North Western	11 887.65	2 961	1 479 791	124	$1.05	$131	4.2	3 204 619	4.08
Chicago Great Western	1 892.85	2 962	308 939	163	1.24	202	5.5	4 796 368	4.22
Chicago, Milwaukee, St.Paul & Pac.	13 739.78	3 083	2 386 983	174	1.18	205	5.6	3 556 173	5.76
Chicago, St.Paul, Minpls.& Omaha	2 211.20	2 963	375 549	170	1.21	206	5.7	3 271 171	6.29
Duluth, Missabe & Iron Range	1 106.00	2 980	112 583	102	1.47	150	3.4	4 425 553	3.39
Duluth, South Shore & Atlantic	517.75	2 843	105 789	204	0.64	130	7.2	1 570 380	8.30
Duluth, Winnipeg & Pacific	209.78	2 927	66 702	318	0.72	230	10.9	2 701 301	8.51
Great Northern	9 881.45	3 091	1 413 307	143	1.10	185	4.6	4 050 908	4.57
Green Bay & Western	283.22	2 880	98 571	348	0.89	308	12.1	1 855 596	16.62
Lake Superior & Ishpeming	232.39	3 000	42 604	183	0.69	127	6.1	947 377	13.43
Minneapolis & St.Louis	1 556.09	3 040	349 892	225	0.91	204	7.4	1 982 149	10.28
Minneapolis, St.Paul & S.S.Marie	4 931.36	2 947	681 871	138	0.84	117	4.7	2 388 291	4.88
Northern Pacific	8 985.43	2 906	1 193 373	133	1.18	156	4.6	3 431 414	4.55
Spokane International	179.23	2 836	58 813	328	0.46	150	11.6	1 386 254	10.81
Spokane, Portland & Seattle	1 092.54	2 893	288 811	264	1.16	306	9.1	3 511 429	8.71
Total	58 706.74	3 001	8 963 578	153	1.13	172	5.1	3 408 415	5.04
CENTRAL WESTERN REGION:									
Alton	1 507.24	3 020	368 168	244	1.32	323	8.1	4 677 226	6.91
Atchison, Topeka & Santa Fe	19 325.62	3 037	1 755 435	91	1.25	113	3.0	4 515 393	2.51
Chicago, Burlington & Quincy	12 295.87	3 088	1 673 856	136	1.28	175	4.4	3 830 771	4.56
Chgo., R.I.& Pac. (Inc.CRIG)	9 790.36	3 083	1 064 945	109	0.96	104	3.6	3 945 374	2.63
Colorado & Southern	887.[illegible]	3 069	89 260	101	1.19	120	3.3	3 220 576	3.72
Denver & Rio Grande Western	3 277.97	3 122	180 798	55	1.05	58	1.8	3 837 012	1.51
Denver & Salt Lake	315.37	3 054	41 218	131	1.29	169	4.3	2 594 470	6.52
Fort Worth & Denver City	950.06	2 823	83 564	88	1.13	100	3.1	2 895 247	3.45
Nevada Northern	191.02	2 870	36 497	191	0.87	167	6.7	830 330	19.93
Northwestern Pacific	4 [illegible].75	2 920	79 282	17[illegible]	0.75	130	5.9	2 019 869	6.44
Southern Pacific	12 242.33	3 036	1 243 [illegible]14	102	1.13	115	3.3	6 541 795	1.78
Toledo, Peoria & Western	270.64	3 168	80 150	217	1.37	298	6.9	2 774 378	10.72
Union Pacific	13 147.87	2 824	2 099 328	160	1.12	178	5.7	6 472 032	2.75
Utah	72.21	2 840	5 408	75	1.12	159	2.6	3 176 436	5.01
Western Pacific	1 469.73	2 972	517 870	352	1.14	402	11.9	6 280 077	6.43
Total	76 208.[illegible]	3 000	9 299 593	122	1.16	142	4.1	4 930 755	2.88
SOUTHWESTERN REGION:									
Burlington-Rock Island	208.16	3 130	19 216	92	0.98	91	2.9	1 922 377	4.72
Gulf Coast Lines:									
Beaumont, Sour Lake & Western	139.79	2 977	15 916	114	1.14	130	3.8	6 [illegible]76 438	2.02
New Orleans, Texas & Mexico	243.02	3 039	29 191	120	1.14	148	4.2	3 390 976	4.37
St.Louis, Brownsville & Mexico	749.45	3 026	98 198	131	1.08	142	4.3	3 210 880	4.41
San Antonio, Uvalde & Gulf	359.80	2 883	41 825	116	1.08	125	4.0	1 344 389	9.32
International-Great Northern	1 474.44	2 999	177 694	121	1.02	123	4.0	3 577 [illegible]	3.43
Kansas City Southern	1 257.93	3 169	157 190	133	1.05	140	4.2	4 401 324	3.17
Kansas, Oklahoma & Gulf	352.93	2 960	13 762	53	0.98	52	1.8	[illegible] 139 886	2.44
Louisiana & Arkansas	910.30	3 245	150 213	198	0.87	173	6.1	2 932 109	5.96
Midland Valley	330.77	2 965	26 [illegible]36	70	1.03	72	2.4	981 107	7.34
Missouri & Arkansas	37[illegible].32	3 116	110 401	303	0.48	147	9.9	1 198 778	12.[illegible]
Missouri-Kansas-Texas Lines	4 067.52	3 144	307 354	76	0.96	73	2.4	3 305 680	2.21
Missouri Pacific	8 967.02	3 006	1 501 025	167	1.03	173	5.4	4 736 250	3.65
Oklahoma City-Ada-Atoka	141.36	2 879	17 214	122	0.37	45	4.2	437 415	10.31
St.Louis-San Francisco	6 397.18	3 147	66[illegible]8	120	1.03	1[illegible]3	3.8	3 [illegible]6 354	3.75
St.Louis, San Francisco & Texas	153.15	3 1[illegible]	27 [illegible]21	172	1.02	185	5.3	2 795 449	6.61
St.Louis Southwestern Lines	1 863.27	3 168	309 213	166	1.16	193	5.2	4 533 031	4.26
Texas & New Orleans	5 637.44	2 723	304 602	143	0.88	125	5.2	3 415 307	3.67
Texas & Pacific	2 427.91	2 920	274 433	112	1.02	114	3.8	4 907 324	2.33
Texas Mexican	203.81	3 168	39 326	193	1.05	203	6.1	627 555	32.29
Total	36 279.67	3 037	4 931 335	136	0.99	135	4.5	3 776 514	3.57
Grand Total - United States	336 833.30	2 994	43 134 273	128	1.22	156	4.3	5 096 941	3.07
CANADIAN ROADS:									
Canadian National	26 862	2 932	5 758 287	214	0.81	173	7.3	2 914 838	5.94
Canadian Pacific	21 274	2 850	5 064 394	144	0.85	122	5.1	5 054 440	4.02
Temiskaming & Northern Ontario	574	2 900	157 500	287	0.65	174	8.8	2 494 965	6.90

Col.3 derived by dividing Col.7 Table A, by Col.8 of same table.
Col.4 is total of cols. 2 and 4 of Table A.
Col.5 derived by dividing total of Cols.2 and 4 Table A, by Col.3 of same table.
Col.6 is weighted average of costs shown in Cols.3 and 5 of Table A.
Col.7 is total cost of ties shown in Cols.2 and 4 Table A, divided by Col.8 of same table.
Col.8 is ratio of total new ties (Cols.2 and 4 Table A) to Col.9 of same table.
Col.9 derived by dividing Col.10 Table A, by Col.8 of same table.
Col.10 is total cost of ties shown in Cols.2 and 4 Table A, divided by Col.10 of same table.

Source: Compiled from annual reports of Class I railways to the Interstate Commerce Commission.

Compiled by
Association of American Railroads
Bureau of Railway Economics
Washington, D.C.

ing up to
ngs

F. Brown,
lner, W. R.
ury, W. D.

e intention,
rossties.
recommends

to read as

3, 7 inches

ended:
e of 8-foot

the 8-foot

Campbell,
kson, Roy

the subject

ublished in

mittee 3—
ne splitting
as consid-
roads. The
procedures
ers to the
marized as

TABLE C

NUMBER AND AGGREGATE COST OF NEW WOODEN CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF NEW WOODEN TIE RENEWALS TO TOTAL CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and large Canadian roads, by years, and for the average of the five years 1936 to 1940, inclusive

Note: All figures are exclusive of [illegible] ties.

Road	Number of new wooden cross tie renewals per mile of maintained track						Aggregate cost of new wooden cross tie renewals per mile of maintained track						Per cent new wooden cross tie renewals to all ties in tracks					
	1936	1937	1938	1939	1940	5 year average	1936	1937	1938	1939	1940	5 year average	1936	1937	1938	1939	1940	5 year average
NORTH-WESTERN REGION:																		
Chicago & North Western	143	149	139	140	124	139	$126	$139	$143	$145	$131	$137	4.8	5.0	4.7	4.7	4.2	4.7
Chicago Great Western	151	178	157	157	163	161	185	225	200	184	202	199	5.1	6.0	5.3	5.3	5.5	5.4
Chicago, Milwaukee, St. Paul & Pac.	212	138	125	177	174	165	211	135	125	200	205	175	7.1	4.6	4.1	5.8	5.6	5.4
Chicago, St. Paul, Minpls. & Omaha	167	189	182	176	170	177	131	178	187	221	206	187	5.6	6.4	6.1	5.9	5.7	5.9
Duluth, Missabe & Iron Range	76	120	63	84	102	89	110	148	82	117	150	121	2.5	4.0	2.1	3.0	3.4	3.0
Duluth, South Shore & Atlantic	223	247	193	173	204	209	126	152	118	106	130	126	7.8	8.7	6.8	6.3	7.2	7.4
Duluth, Winnipeg & Pacific	376	306	320	293	318	323	223	210	238	209	230	222	12.5	10.2	10.7	9.8	10.9	10.8
Great Northern	112	121	106	132	143	123	126	141	132	170	185	151	3.6	3.9	3.4	4.3	4.6	4.0
Green Bay & Western	441	352	320	333	348	339	391	343	314	293	308	331	15.3	12.2	11.1	11.5	12.1	12.4
Lake Superior & Ishpeming	229	193	168	148	181	181	136	125	114	101	127	121	7.5	6.4	5.6	4.9	6.1	6.1
Minneapolis & St. Louis	206	199	193	221	225	210	168	195	193	197	224	191	6.8	6.6	6.5	7.3	7.4	6.9
Minneapolis, St. Paul & S.S. Marie	179	167	161	133	138	136	162	143	122	111	117	131	6.1	5.7	5.5	4.5	4.7	5.3
Northern Pacific	122	129	128	136	133	130	126	126	144	160	156	142	4.2	4.4	4.4	4.7	4.6	4.5
Spokane International	341	370	329	351	328	344	153	168	150	160	150	156	12.1	13.1	11.6	12.4	11.6	12.2
Spokane, Portland & Seattle	186	173	237	183	264	205	120	150	223	200	306	201	5.5	5.7	7.3	6.3	9.1	6.8
Total	160	147	137	152	153	150	155	144	142	168	172	156	5.4	4.9	4.6	5.1	5.1	5.0
CENTRAL WESTERN REGION:																		
Alton R.R.	240	233	248	251	244	243	287	276	352	354	323	322	7.9	7.7	8.2	8.3	8.1	8.0
Atchison, Topeka & Santa Fe (see note)	120	125	84	101	91	104	136	143	102	118	113	122	4.0	4.1	2.8	3.3	3.0	3.4
Chicago, Burlington & Quincy	138	149	153	155	136	146	170	186	201	201	175	187	4.5	4.8	4.9	5.0	4.4	4.7
Chicago, Rock Island & Pacific (see note)	100	126	118	120	109	115	96	117	122	119	104	112	3.3	4.2	3.9	4.0	3.6	3.8
Colorado & Southern	123	86	78	87	101	95	100	59	92	101	120	101	4.1	2.9	2.6	2.9	3.3	3.2
Denver & Rio Grande Western	151	137	71	76	55	100	147	145	93	51	58	105	4.8	4.4	2.6	2.4	1.8	3.2
Denver & Salt Lake	468	395	42	174	131	242	583	502	60	234	169	311	15.3	12.9	1.4	5.7	4.3	7.9
Fort Worth & Denver City	64	73	94	104	88	85	67	78	106	121	100	94	2.1	2.4	3.1	3.5	3.1	2.8
Nevada Northern	131	140	162	173	191	159	102	112	143	144	167	134	4.6	4.9	5.6	6.0	6.7	5.6
Northwestern Pacific	94	128	104	177	173	129	43	93	84	138	130	97	2.2	4.4	3.6	6.1	5.9	4.4
Southern Pacific Co.- Pac. Lines	77	92	93	95	102	93	91	107	114	108	113	107	2.6	3.1	3.3	3.1	3.3	3.1
Toledo, Peoria & Western	278	399	356	225	217	295	372	568	505	313	298	411	8.8	12.6	11.2	7.1	6.9	9.3
Union Pacific	159	178	150	155	160	160	166	183	170	178	178	175	9.6	6.3	5.3	5.5	5.7	6.5
Utah Ry.	259	155	97	79	75	133	403	228	153	173	159	223	10.0	5.8	3.6	2.8	2.6	5.0
Western Pacific	361	373	243	313	352	332	237	361	282	371	402	331	12.2	13.2	8.2	10.6	11.9	11.2
Total	132	142	121	128	122	129	140	156	143	150	142	146	4.4	4.7	4.0	4.3	4.1	4.3
SOUTH-WESTERN REGION:																		
Burlington-Rock Island	76	69	59	87	92	77	59	41	54	75	91	64	2.4	2.2	1.9	2.8	2.9	2.4
Gulf Coast Lines:																		
Beaumont, Sour Lake & Western	77	110	104	102	114	101	85	122	111	104	130	110	2.6	3.7	3.5	3.4	3.8	3.4
New Orleans, Texas & Mexico	119	175	217	211	130	170	124	190	224	208	143	179	3.9	5.7	7.1	6.9	4.2	5.6
St. Louis, Brownsville & Mexico	81	113	115	121	131	112	82	120	117	121	142	116	2.7	3.7	3.8	4.0	4.3	3.7
San Antonio, Uvalde & Gulf	89	125	164	147	116	128	110	142	180	150	125	141	3.1	4.3	5.7	5.1	4.0	4.4
International-Great Northern	106	101	105	116	121	110	103	102	105	115	123	110	3.5	3.4	3.5	3.9	4.0	3.7
Kansas City Southern	117	132	137	143	133	132	121	137	143	150	140	138	3.7	4.2	4.3	4.5	4.2	4.2
Kansas, Oklahoma & Gulf	233	205	172	128	53	158	245	206	182	136	52	164	7.8	6.8	5.7	4.3	1.8	5.3
Louisiana & Arkansas (see note)	277	225	274	217	193	238	176	156	201	166	173	175	8.9	7.2	8.8	6.7	6.1	7.5
Midland Valley	115	115	92	86	70	96	120	119	93	91	72	99	3.8	3.8	3.1	2.9	2.4	3.2
Missouri & Arkansas	405	430	346	351	303	367	161	191	145	156	147	160	13.0	13.8	11.1	11.2	9.9	11.8
Missouri-Kansas-Texas Lines	110	124	99	116	76	105	107	116	105	118	73	104	3.5	3.9	3.1	3.7	2.4	3.3
Missouri Pacific	214	195	171	188	167	187	204	212	185	196	173	194	6.9	6.3	5.5	6.1	5.4	6.0
Oklahoma City-Ada-Atoka	211	233	243	241	122	210	136	123	147	128	45	116	7.0	7.8	8.1	8.4	4.2	7.1
St. Louis-San Francisco	199	206	180	142	120	169	206	209	192	150	123	176	6.3	6.5	5.7	4.5	3.8	5.4
St. Louis, San Fran. & Texas	266	165	152	166	182	186	262	142	145	166	185	180	8.4	5.2	4.8	4.9	5.8	5.8
St. Louis Southwestern Lines	179	190	158	176	166	174	184	205	177	205	193	193	5.7	6.0	5.0	5.6	5.2	5.5
Texas & New Orleans	122	132	133	135	143	133	100	122	129	126	125	120	4.5	4.8	4.8	5.0	5.2	4.9
Texas & Pacific	105	88	94	104	112	101	95	88	97	104	114	100	3.5	3.0	3.2	3.6	3.8	3.4
Texas Mexican	241	266	135	111	193	189	256	306	156	124	203	209	8.4	9.2	4.3	3.5	6.1	6.3
Total	167	165	121	151	136	154	156	164	154	151	135	152	5.5	5.4	5.0	5.0	4.5	5.1
Grand Total - United States	136	137	120	132	128	131	145	156	142	159	156	152	4.5	4.6	4.0	4.4	4.3	4.4
CANADIAN ROADS:																		
Canadian National (See note)	242	213	214	214	214	219	189	174	172	171	173	176	8.5	7.4	7.3	7.7	7.6	7.7
Canadian Pacific (See note)	160	164	166	136	144	158	142	143	142	124	125	135	5.7	5.8	5.9	5.5	5.1	5.8
Temiskaming & Nor. Ontario	209	241	251	257	287	245	151	160	180	179	174	169	7.4	8.4	8.8	8.9	8.8	8.4

Note: Statement applies to Class I roads and includes consolidated data for Class I roads merged during the period 1936 to 1940 as follows:
Atchison, Topeka & Santa Fe - Includes Fort Worth & Rio Grande.
Chicago, Rock Island & Pacific - Includes Chicago, Rock Island & Gulf.
Gulf Mobile & Ohio - Consolidation of Gulf, Mobile & Northern and Mobile - Ohio.
Louisiana & Arkansas - Includes Louisiana, Arkansas & Texas.
Southern Railway - Includes Northern Alabama.
Canadian National Rys.- includes lines in New England; Grand Trunk Western; and Duluth, Winnipeg & Pacific.
Canadian Pacific - includes all lines.

Compiled by
Association of American Railroads
Bureau of Railway Economics
Washington, D.C.

Report on Assignment 5

Investigate and Report on the Dimensions of Ties, and Bring up to Date the Information in the 1924 and 1932 Proceedings

W. J. Burton (chairman, subcommittee), W. C. Bolin, W. H. Brameld, H. F. Brown, F. G. Campbell, S. B. Clement, R. L. Cook, E. J. Cullen, W. E. Gardner, W. R. Gillam, C. T. Jackson, J. E. Lockhart, A. F. Maischaider, E. F. Salisbury, W. D. Simpson, Raymond Swenk.

This assignment has been completed except as to carrying out the intention, announced last year, of modifying the Manual so as to provide for longer crossties.

Based upon the studies and data previously reported, your committee recommends the following change and addition to the Manual.

Under the heading, Dimensions of Ties, page 3–15, change Paragraph 3 to read as follows:

3. For heavy traffic lines ties meeting the standard specifications for size 3, 7 inches thick, and sizes 4 and 5 should be used.

Add paragraph 5 to read as follows:

"5. Where ties shorter than 9 foot are in use, the following is recommended:

(a) The adoption of 9-foot ties and the discontinuance of the purchase of 8-foot ties as rapidly as practicable and economical.

(b) The use of 9-foot ties at least for lines of heavy traffic.

(c) The adoption of the 9-foot length whenever a change is made from the 8-foot length."

Report on Assignment 6

Cause and Control of Splitting in Railroad Ties

R. E. Butler (chairman, subcommittee), R. S. Belcher, W. H. Brameld, F. G. Campbell, E. J. Cullen, H. R. Duncan, W. E. Gardner, B. D. Howe, C. T. Jackson, Roy Lumpkin, E. F. Salisbury, Raymond Swenk, C. D. Turley, A. W. White.

This is a progress report, presented as information, with the request that the subject be continued.

An introductory report on this subject was presented in 1940 and published in Volume 41, page 654, of the Proceedings.

During the past year a questionnaire was submitted to members of Committee 3—Ties, to determine what their respective railroads were doing to minimize the splitting of ties. Twenty-two railroads are represented on this committee, and it was considered that the answers would prove a cross-section of present practices on all roads. The committee has also visited 14 seasoning yards and observed the anti-splitting procedures of 18 railroads, 9 of which were represented on the committee. The answers to the questionnaire and the observations made during field inspections may be summarized as follows:

1. Do you use anti-splitting devices in your hardwood ties?

All roads but two use an anti-splitting device in their hardwood ties. One of these ceased applying irons for a year as an experiment, and the other uses only 5 to 10 percent of hardwood ties.

2. If so, what type of iron is used?

The form of iron most commonly used is the "S", and the "C" is a close second. Also used in substantial quantity is the form with extended arms. Some roads use crinkled irons in all these forms. A few use irons with a rib or barb, designed to retain the iron in the tie.

3. Gage of iron used?

The gage of iron used for anti-splitting devices ranges from 12 to 14, with 13 predominating.

4. Length of iron used?

The iron used is usually 5 or 6 in. long, with a few 5½ and 6½ in.

5. When are ties ironed?

Practice varies as to the proper time to apply irons, but the majority apply them promptly after stacking for seasoning. The minority apply irons subsequently and progressively as splits develop. Two roads have the irons applied by the tie-producing contractors in their yards along the right-of-way before shipping the ties to the seasoning yard. Two roads allow a period of 90 days to elapse before applying irons, basing this practice on two assumptions:

(a) That irons become loose because the wood surrounding an iron shrinks away from it as the wood dries.

(b) That 90 days of seasoning will reduce the moisture content at the end of the tie as low as it will go during the longer period required to season the whole tie for treatment.

One road irons such ties as give evidence of splitting when stacked. Further attention to ironing is not given until ties are trammed for treatment, when all split ties are ironed.

6. What ties are ironed?

Generally, all hardwood ties are ironed. However, some roads iron only split ties or ties considered likely to split.

7. Number of irons applied to each end?

Uniformity in practice does not prevail, the answers being about equally divided as follows:

(1) Two irons in both ends of all ties;
(2) Two irons in sizes 4 and 5, and one iron in sizes 1, 3 and 3;
(3) One iron in both ends of all ties;
(4) As many irons as deemed necessary at time of application.

One road starts with one iron and applies more if splits make them necessary.

Based on observations made and opinions developed to date, it appears that:

1. Ironing is more effective when it prevents splits, than when used in an effort to stabilize a split already started.

2. Best results will be obtained by application promptly after stacking, thus minimizing any loss that may occur from uncontrolled splitting.

3. In any selective system of ironing there is no way to predetermine which ties will split; therefore if ironing is delayed until splitting is evident the split is liable to be beyond control when discovered.

4. The trend is toward two irons in each end of all ties as the proportion of rectangular sawed ties increases, since one iron cannot be placed so as to prevent deep splits progressing from more than one surface.

5. Proper ironing requires knowledge and skill based on training and experience. Many of the men performing this work lack the essential expertness, consequently the results are often unsatisfactory.

Report of Committee 17—Wood Preservation

H. R. Duncan, *Chairman,*
W. P. Arnold
S. J. Buckman
Walter Buehler
C. M. Burpee
C. S. Burt
G. B. Campbell
W. F. Clapp
E. A. Craft
John Foley
W. R. Goodwin
L. B. Holt
H. E. Horrocks
R. S. Hubley
R. P. Hughes
M. F. Jaeger
A. L. Kammerer
A. M. Knowles
A. J. Loom
F. B. Robins
R. S. Belcher, *Vice-Chairman,*
Henry Schmitz
L. B. Shipley
O. C. Steinmayer
G. C. Stephenson
T. H. Strate
W. A. Summerhays
J. E. Tiedt
Hermann von Schrenk
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, embracing revisions to bring AREA practice up to date .. page 406

2. Service test records for treated ties.

   Progress report—presented as information ..... page 413

3. Destruction by marine organisms and possible ways of prevention.

   Progress report—presented as information ..... page 435

4. Effect of preservative treatment by use of (a) Creosote and petroleum, and (b) Zinc chloride and petroleum.

   Final report, presented as information ..... page 449

5. Destruction by termites and possible ways of prevention.

   Progress report—presented as information ..... page 461

6. Revision of specifications for the treatment of Douglas fir.

   Final report, recommended for adoption to replace corresponding material now in the Manual ..... page 462

7. Incising forest products, collaborating with Committee 3—Ties.

   No report.

8. Investigations being made for the determination of toxicity value of creosote and creosote mixtures.

   No report.

9. Reasons for and extent of use of creosote-petroleum mixture treatment.

   No report.

10. Specifications for creosote-petroleum treatment.

    No report.

11. Use of straight tar for tie treatment and results obtained.

    No report.

12. Critically review the specifications for creosote with attention to changes in the process of manufacture and with regard to limiting the residue above 355 deg. C.

    No report.

THE COMMITTEE ON WOOD PRESERVATION,
H. R. DUNCAN, *Chairman.*

Report on Assignment 1

Revision of Manual

John Foley (chairman, subcommittee), W. P. Arnold, R. S. Belcher, C. S. Burt, W. F. Clapp, R. P. Hughes, M. F. Jaeger, A. L. Kammerer, A. J. Loom, Henry Schmitz, L. B. Shipley, T. H. Strate, Hermann von Schrenk.

The following revisions of matter in the Manual are presented for adoption in order that AREA recommended practice may be up-to-date.

Manual page 17–1.—Because some of the statements appearing under the heading, "General Provisions," duplicate others that are more appropriate elsewhere, because still others conflict with statements in prospect and because most of them are outmoded by developments since 1926, your committee offers the material under the heading, "Wood Preserving Fundamentals" on page 407, with the recommendation that it be adopted for publication in the Manual in place of the material now appearing on page 17–1.

Manual pages 17–5 to 17–11.—Because the Specifications for Treating Processes are not in accord with accepted procedure as practiced now and for sometime in the past. your committee offers on following pages new Specifications for Treating Processes, to replace those appearing in the Manual.

Manual page 17–14.—The single Creosote-Coal Tar Solution as specified in the Manual has not proved sufficient for the varied requirements of those practicing preservative treatment; therefore, your committee presents on following pages Specifications for Creosote-Coal Tar Solutions that provide a choice of several solutions, which are recommended for adoption and publication in the Manual to replace the specifications appearing on page 17–14.

Manual pages 17–65 to 17–67.—Because all of the statements appearing under the heading, "Preparation and Handling of Wood Before and After Treatment," do not have specific relation to preservative treatment and some prescribe treatments which are, or should be recommended by committees responsible for the effective use of wood, whether preserved or not, your committee recommends the deletion of the matter under the above-mentioned heading and its replacement by the matter appearing on following pages under the heading, "Wood Preserving Plant Practice."

Manual page 17–68.—Statements appear on this page under the following titles:

"Practicability of Boring Bridge and Switch Ties for Spikes Before Treatment
"Service Test Records of Structural Timber, Including Piling."

Because these are not responsive to the titles given them and because they are mere expressions of a type not appropriate for inclusion in the Manual, it is recommended that they be deleted.

WOOD PRESERVING FUNDAMENTALS

Preservative treatment is of value primarily for kinds of wood not naturally resistant to decay. Treatment of such non-resistant woods makes available lumber and timber not economically usable untreated.

The heartwood of most naturally-durable woods resists penetration by preservative, yet its life is generally extended by treatment, even though the depth of penetration is slight.

Preservative treatment will not restore any loss of strength resulting from defects of any kind; consequently only wood free of defects which will render it unfit for use can be treated to advantage.

Wherever exposed to decay or attack by other wood-destroying organisms, all forest products not naturally resistant to deterioration by such organisms can be treated preservatively at a saving in annual cost.

Wood needs to be conditioned for preservative treatment, by a procedure which will render it receptive to penetration by preservative without materially reducing its strength.

Artificial conditioning is necessary in cases of large material, which in some localities will not dry in the air without deterioration during any season of the year, and when the time for proper air seasoning is insufficient.

The conditioning of wood in steam is particularly adapted to kinds which do not check materially, split, or warp when subjected to high temperatures. Steaming is applied to Douglas fir and to hardwoods only when a salt is the preservative.

Heating wood in preservative at atmospheric pressure is undertaken to assure the penetration of some preservative under pressure when the removal of appreciable quantities of water is deemed unnecessary.

Heating in oil under a vacuum conditions Douglas fir and most hardwoods which do not check materially, split, or warp when subjected to high temperatures, provided the treating equipment includes adequate condensers and measuring tanks.

Bark on wood to be treated prevents the penetration of preservative, and any strip of inner bark wider than ½ inch or closer to another than two inches is objectionable.

To avoid any cutting into preserved parts, the complete manufacture in its final form of wood to be treated is advisable. Preboring to accommodate fastening devices insures the introduction of preservative to the wood surrounding the holes.

Incising woods difficult to penetrate and incising exposed heartwood resistant to treatment insures the presence of preservative where required.

Creosote is the standard wood preservative for all purposes where a colorless, odorless, and paintable product is not required. It has a high degree of permanence and is highly toxic to fungi, insects, and marine borers.

Creosote is often mixed with coal tar or petroleum to decrease the cost, increase the water-repelling properties, and retard the evaporation of the preservative; but creosote-coal tar solutions are not suitable for poles nor are creosote-petroleum mixtures to be used in marine structures.

Zinc chloride is the standard wood preservative for uses where a colorless, odorless, and paintable product is required. It is forced into wood in an aqueous solution and is highly toxic; but it is less permanent than creosote in localities where the wood is in contact with water or subject to periodic wetting. Wood treated with zinc chloride will shrink in place if not kiln or air dried after treatment and before installation.

Careless handling of treated wood is apt to expose areas not reached by the preservative; consequently the use of pointed tools other than end hooks is objectionable.

Hot creosote will protect surfaces exposed by necessary boring or cutting if the holes are filled with the oil (preferably by means of portable pressure equipment) and the cuts painted twice, followed by a coating of coal-tar pitch sealing compound. Treated plugs driven into holes are insurance against the entrance of fungi.

The checking which exposes untreated wood can be prevented through protecting creosoted material from the direct rays of the sun, while being held unused for any reason, by covering it with at least 2 inches of soil.

SPECIFICATIONS FOR TREATING PROCESSES*

I GENERAL REQUIREMENTS

101. The following requirements (sections 102 to 108, and 301 to 605, inclusive) apply to each of the treatment processes. If these requirements are to be modified to meet special conditions, complete detailed instructions shall be given.

102. *Plant Equipment.*—Treating plants shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in acceptable, proper working condition. The apparatus and chemicals necessary for making the analyses and tests required by the Purchaser shall also be provided by plant operators, and kept in condition for use at all times.

103. *Conditioning.*—(Material) shall be conditioned by air-seasoning, by steaming, or by heating in oil either under vacuum or at atmospheric pressure, or by a combination of them as agreed upon, in such a manner as will not cause injurious checking, splitting, or warping.

104. When air-seasoning is used, the (material) shall be treated before it begins to decay.

105. When steam-conditioning is used,[2] (material) shall be steamed in the cylinder at not more than 259 degrees F. (approximately 20 pounds pressure per square inch), for not less than 6 hours and not more than 18 hours, which temperature maximum shall not be reached in less than one hour. The duration of the steaming shall be based on consideration of the shape, cross-sectional area and moisture content of the (material). The cylinder shall be provided with vents to relieve it of air and insure proper distribution of steam. After steaming is completed a minimum vacuum of 22 inches at sea level shall be maintained for not less than 60 minutes or more than 180 minutes. The cylinder shall be relieved continuously or frequently enough to prevent condensate from accumulating in sufficient quantity to reach the wood. Before the preservative is introduced the cylinder shall be drained of condensate.

106. When conditioning by heating in oil is used, the oil shall cover the (material) in the cylinder. The temperature of the oil during the conditioning period shall not exceed 220 degrees F.[3] If a vacuum is then drawn, it shall be of sufficient intensity to evaporate water from the (material) at the temperature of the oil. The intensity of the vacuum, or the temperature of the oil, or both, shall be adjusted so as to regulate the evaporation of the water satisfactorily. The conditioning shall continue until the (material) is sufficiently heated and enough water removed to permit proper penetration. The oil shall be removed from the cylinder before an empty-cell process is applied.

---

* Excluding Douglas fir, larch or tamarack.

[2] Steam conditioning is not recommended for oak material.

[3] Limited, in the case of oak material, to 210 degrees F., or when the width is more than twice the thickness, to 180 degrees F.

107. *Sorting and Spacing.*—Whenever it is practicable, the (material) in any charge shall consist of pieces similar in size, moisture content, and receptivity to treatment, and so separated as to insure contact of heating medium with all surfaces.

108. *Machining.*—So far as practicable, all adzing, boring, chamfering, framing, gaining, incising, surfacing, trimming, etc., shall be done prior to treatment.

II TREATMENT

Oil Treatment

201. *Manner of Treatment.*—Following the conditioning period, the (material) shall be treated by an empty-cell process whenever practicable, to obtain as deep and uniform penetration as possible with the retention of preservative stipulated. (Material) shall be treated by the full-cell process only when the maximum net retention is desired and where pressure is held to refusal, or when the stipulated retention is greater than can be obtained by the use of an empty-cell process. The ranges of pressure, temperature and time duration shall be controlled so as to get the maximum penetration by the quantity of preservative injected.

STANDARD PROCESSES

Empty-Cell—Lowry and Rueping[4]

202. (Material) shall be subjected to atmospheric air pressure or to higher initial air pressure of the necessary intensity and duration. The preservative shall be introduced until the cylinder is filled, the air pressure being maintained constant during the filling operation. The pressure shall be raised to not more than 200 pounds per square inch. (Material) shall be held under pressure until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by ejection of surplus preservative from expansion of the air initially introduced and by a quick high vacuum.

203. The temperature of the preservative during the entire pressure period shall be not more than 200 degrees F., but shall average at least 180 degrees F.

204. After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

Full-Cell—Bethel

205. (Material) shall be subjected to a vacuum of not less than 22 inches at sea level for not less than 30 minutes. The preservative shall be introduced until the cylinder is filled without first breaking the vacuum. The pressure shall be raised to not more than 200 pounds per square inch. (Material) shall be held under pressure until there is obtained the volumetric injection that will insure the stipulated retention, or until the wood is treated to refusal.

206. The temperature of the preservative during the entire pressure period shall be not more than 200 degrees F., but shall average at least 180 degrees F.

207. After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

[4] If the cylinder is filled at atmospheric air pressure, the process is that known as Lowry. If initial air pressures higher than atmospheric are used, the process is that known as Rueping.

Salt Treatment[5]

208. *Manner of Treatment.*—Following the conditioning period, the (material) shall be treated by an empty-cell process or by the full-cell process. The treating solution shall be of uniform concentration and no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption practicable with the process used. The ranges of pressure, temperature and time duration shall be controlled so as to get the maximum penetration by the quantity of preservative injected.

STANDARD PROCESSES

Empty-Cell—Lowry and Rueping[6]

209. (Material) shall be subjected to atmospheric air pressure or to higher initial air pressure of the necessary intensity and duration. The preservative solution shall be introduced until the cylinder is filled, the air pressure being maintained constant during the filling operation. The pressure shall then be raised to not more than 200 pounds per square inch. (Material) shall be held under pressure until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by ejection of surplus preservative solution from expansion of the air initially introduced and by a quick high vacuum.

210. After pressure is completed the cylinder shall be emptied speedily of preservative solution, and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping solution.

Full-Cell—Burnett

211. (Material) shall be subjected to a vacuum of not less than 22 inches at sea level for not less than 30 minutes. The preservative solution shall be introduced until the cylinder is filled without first breaking the vacuum. The pressure shall be raised to not more than 200 pounds per square inch. (Material) shall be held under pressure until there is obtained the volumetric injection that will insure the stipulated retention, or until the wood is treated to refusal.

212. The temperature of the preservative during the entire pressure period shall not be sufficient to change the character of the solution.

213. After pressure is completed the cylinder shall be emptied speedily of preservative solution, and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping solution.

III RESULTS OF TREATMENT

301. *Retention of Preservative.*—The net retention in any charge shall be not less than 90 percent of the quantity of preservative that may be specified; but the average retention by the (material) treated under any contract or order and the average retention of any 5 consecutive charges shall be at least 100 percent of the quantity specified. The amount of preservative retained shall be calculated from reading of working-tank gages, or scales, or from weights before and after treatment of loaded trams on suitable track scales, with the necessary corrections for changes in moisture content.

[5] Not suitable for the treatment of piles or poles.

[6] If the cylinder is filled at atmospheric air pressure, the process is that known as Lowry. If initial air pressures higher than atmospheric are used, the process is that known as Rueping.

302. The volume of oil preservatives shall be calculated on the basis of 100 degrees F. Calculations of volume or weight shall be made by the use of temperature or specific-gravity factors contained in the Volume and Specific Gravity Correction Tables of the American Railway Engineering Association.

303. The weight of salt preservatives shall be based on the dry salt, as determined by the standard methods of analysis of the AREA.

304. The amount of preservative retained shall be as follows, depending on use requirements, and as stipulated in Purchaser's order and in accordance with Section 301.[7]

305. .... pounds of ..... per cubic foot of wood in charge.

(To be filled out further or where two or more of the standard preservatives may be used.)

306. *Penetration.*—The penetration shall be specified by the Purchaser in accordance with use requirements, and with regard for the kind and character of the wood and the form of the material.

307. *Determination of Penetration.*—Penetration shall be determined by boring enough pieces to be representative of each charge, in accordance with the practice of the Customer.

308. *Plugging Penetrance Test Holes.*—All holes made for determining penetration of preservative shall be filled with tight-fitting treated plugs or with untreated plugs of durable heartwood approved by the Purchaser.

IV PRESERVATIVES

The preservatives used shall be whichever of the following standards of the AREA is stipulated:

.....
.....
.....
.....

V INSPECTION

Inspection of (material) for conformity to the requirements of this specification shall be in accordance with the practice of the Customer.

VI RETREATMENT

601. (Material) not conforming to the stipulated minimum requirements may be retreated and may be reoffered for acceptance, under the following conditions:

602. The retreatable (material) in a charge of untreated (material) shall not exceed 10 percent of the total quantity in the charge.

603. The limits for temperature of steam or preservative and for preservative pressure shall not be exceeded.

604. The amount of preservative injected during the retreatment of rejected (material) shall be at the discretion of the plant operator, provided the net retention is not less than the minimum requirements.

605. In the computation of the required minimum net retention for any charge of both rejected and untreated (material), all (material) in the charge shall be considered as untreated.

[7] For recommended quantities, see Manual, Table 1701, pp. 17–3, 4.

SPECIFICATIONS FOR CREOSOTE-COAL TAR SOLUTIONS

The material shall be a pure coal-tar product (see Note 1) obtained from the high temperature carbonization of coal. It may be either a coal-tar distillate oil or a solution of coal tar in distillate oil. It shall comply with the following requirements for the grades below:

	A		*B*		*C*		*D*	
Grade	*Not more than*	*Not less than*	*Not more than*	*Not less than*	*Not more than*	*Not less than*	*Not more than*	*Not less than*
1 Composition:								
Coal-tar distillate, percent by volume		80		70		60		50
2 Water:								
percent by volume ...	3.0		3.0		3.0		3.0	
3 Material insoluble in benzol (see Note 2): percent by weight	2.0		3.0		3.5		4.0	
4 Coke residue (see Note 3): percent by weight ...	5.0		7.0		9.0		11.0	
5 Specific gravity at 38 degrees C. compared with water at 15.57 degrees C.	1.11	1.06	1.12	1.07	1.13	1.08	1.14	1.09
6 Distillation: On a water-free basis the distillate shall be within the following percents by weight:								
Up to 210 degrees C.	5		5		5		5	
Up to 235 degrees C.	25	5	25	5	25	5	25	5
Up to 315 degrees C.		36		34		32		30
Up to 355 degrees C.		60		56		52		48

Note 1.—Owing to the complexity of the chemical composition and physical property of coal-tar creosote, and to the fact that some of the same compounds and properties which characterize coal-tar creosote are found in certain petroleum derivatives, the determination of the purity of creosote is difficult. When there is not certain assurance that the oil is a pure product, the following tests will aid in arriving at an opinion as to its coal-tar origin:

(a) Fraction distilling between 210 and 235 degrees C. is usually solid or contains some solids when cooled to 25 degrees C.

(b) All the fractions up to 315 degrees C. contain tar acids in varying amounts, usually at least 1 percent, calculated on the amount of the fraction tested. (See AREA Manual, pp. 17–39, 40.)

(c) The specific gravity of the fraction between 235 and 315 degrees C. is usually not lower than 1.025 and specific gravity of the fraction between 315 and 355 degrees C. is usually not lower than 1.085 at 38 degrees C., compared with water at 15.5 degrees C. However, some pure coal-tar distillates fall slightly below these limits.

If the sample does not comply with at least one of the foregoing tests, it is undoubtedly not a pure coal-tar creosote.

Note 2.—Samples of creosote-coal tar solution taken from working tanks may show an increase in matter insoluble in benzol as a result of treating operations. Such increases, provided they do not exceed by 1 percent the specification limits, should not cause rejection of the solution if it can be shown that the original fresh solution was of specified quality.

Note 3.—Samples of creosote-coal tar solution taken from working tanks may show an increase in coke residue as a result of treating operations. Such increases, provided they do not exceed by 1 percent the specification limits, should not cause rejection of the solution, if it can be shown that the original fresh solution was of specified quality.

WOOD PRESERVING PLANT PRACTICE

Northern Pacific

(Inspection reports for 1941 are submitted by the U. S. Forest Products Laboratory covering the Hartford, Fair Grounds and University Avenue test tracks of the Chicago, Milwaukee, St. Paul & Pacific.)

CROSS TIE RENEWALS PER MILE OF ALL TRACK MAINTAINED 1911-1940

COMMITTEE 7 AWRA XVII AREA

Year	AT&SF Miles	AT&SF Ties	AT&SF 5 Yr Avg Ties	B&O Miles	B&O Ties	B&O 5 Yr Avg Ties	CB&Q Miles	CB&Q Ties	CB&Q 5 Yr Avg Ties	C&EI Miles	C&EI Ties	C&EI 5 Yr Avg Ties	CCC&StL Miles	CCC&StL Ties	CCC&StL 5 Yr Avg Ties
1911	4215	272	266	9548	206	262				520	84	136	1923	358	389
12	[illegible]	22	273	[illegible]	[illegible]	246				972	89	69	3960	[illegible]	[illegible]
13	[illegible]	96	252	[illegible]	259	249				2908	189	87	[illegible]	[illegible]	[illegible]
14	5660	186	238	[illegible]	228	[illegible]	2684	[illegible]		2346	222	[illegible]	[illegible]	[illegible]	[illegible]
15	5373	225	[illegible]	9424	209	210	2854	[illegible]		[illegible]	255	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	99	230	[illegible]	[illegible]	175	2855	223		1893	264	238	[illegible]	[illegible]	272
17	6277	162	[illegible]	[illegible]	[illegible]	[illegible]	13285	[illegible]		87	[illegible]	235	4890	222	288
18	6459	56	[illegible]	[illegible]	[illegible]	254	1333	[illegible]	209	882	[illegible]	[illegible]	[illegible]	[illegible]	233
19	[illegible]	92	74	[illegible]	203	[illegible]	[illegible]	[illegible]	96	[illegible]	[illegible]	99	4173	20	[illegible]
1920	[illegible]	10	45	[illegible]	251	[illegible]	[illegible]	[illegible]	66	[illegible]	62	189	4177	58	195
21	6900	69	56	[illegible]	229	[illegible]	[illegible]	[illegible]	[illegible]	843	63	32	[illegible]	94	192
22	7280	58	155	[illegible]	226	[illegible]	[illegible]	[illegible]	76	654	[illegible]	[illegible]	4229	43	82
23	7426	78	169	[illegible]	[illegible]	[illegible]	[illegible]	49	[illegible]	662	58	[illegible]	3972	91	[illegible]
24	[illegible]	6	42	[illegible]	192	228	[illegible]	[illegible]	68	166	[illegible]	[illegible]	3948	39	65
25	8355	87	32	[illegible]	[illegible]	[illegible]	[illegible]	52	63	663	26	[illegible]	[illegible]	42	[illegible]
26	8155	[illegible]	25	[illegible]	[illegible]	[illegible]	3403	5	[illegible]	842	[illegible]	[illegible]	[illegible]	[illegible]	144
27	[illegible]	39	2	[illegible]	[illegible]	[illegible]	2866	[illegible]	[illegible]	544	130	6	3818	[illegible]	[illegible]
28	9223	65	128	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	1548	132	[illegible]	3867	[illegible]	[illegible]
29	9046	[illegible]	141	[illegible]	[illegible]	84	2942	63	62	1548	130	118	3340	95	[illegible]
1930	9223	6	151	[illegible]	[illegible]	[illegible]	[illegible]	5	62	1547	99	122	3923	50	98
31	9234	—	38	[illegible]	64	62	2942	56	58	1548	99	[illegible]	4704	[illegible]	93
32	[illegible]	—	38	[illegible]	[illegible]	[illegible]	[illegible]	24	64	1246	100	[illegible]	3509	[illegible]	85
33	[illegible]	3	39	[illegible]	[illegible]	[illegible]	2236	64	125	1363	92	184	4205	[illegible]	[illegible]
34	[illegible]	36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1509	[illegible]	[illegible]	4583	[illegible]	[illegible]
1935	9242	[illegible]	39	[illegible]	[illegible]	67	2683	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	[illegible]
36	9328	9	96	[illegible]	[illegible]	[illegible]	[illegible]	38	96	[illegible]	85	95	3570	[illegible]	[illegible]
37	9395	23	94	[illegible]	[illegible]	56	[illegible]	49	[illegible]	450	186	95	①		
38	9356	[illegible]	30	[illegible]	65	35	2320	32	[illegible]	424		99	①		
39	9494	—	—	[illegible]	59	[illegible]	[illegible]	65	43	[illegible]	3	[illegible]	①		
1940	9472	46	53	[illegible]	[illegible]	[illegible]	[illegible]	57	[illegible]	347	5	[illegible]	①		

Year	CMStP&P Miles	CMStP&P Ties	CMStP&P 5 Yr Avg Ties	CRI&P Miles	CRI&P Ties	CRI&P 5 Yr Avg Ties	DL&W Miles	DL&W Ties	DL&W 5 Yr Avg Ties	Gt Northern Miles	Gt Northern Ties	Gt Northern 5 Yr Avg Ties	Ill's Central Miles	Ill's Central Ties	Ill's Central 5 Yr Avg Ties
1911				9311	255		2514	[illegible]	[illegible]	8390	267	259	8378	299	
12	12120	[illegible]		9808	229	256	[illegible]	131	227	[illegible]	228	256	9438	267	
13	12348	195		[illegible]	[illegible]	[illegible]	2644	28	228	9395	[illegible]	256	9520	[illegible]	
14	1461	223		[illegible]	[illegible]	237	2627	255	[illegible]	[illegible]	232	[illegible]	[illegible]	265	
15	[illegible]	232		10046	209	237	2663	[illegible]	[illegible]	[illegible]	[illegible]	237	9852	253	
16	[illegible]	221	265	10044	222	229	2658	193	248	[illegible]	[illegible]	235	9741	228	260
17	[illegible]	[illegible]	[illegible]	[illegible]	183	[illegible]	2663	157	233	[illegible]	244	238	9922	179	202
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2671	[illegible]	[illegible]	10816	250	181	9852	[illegible]	[illegible]
19	10426	[illegible]	188	10274	158	[illegible]	2673	[illegible]	[illegible]	10430	[illegible]	[illegible]	[illegible]	138	204
1920	[illegible]	[illegible]	[illegible]	10299	[illegible]	32	[illegible]	58	[illegible]	10924	[illegible]	242	10093	230	201
21	[illegible]	[illegible]	[illegible]	10319	169	17	2675	166	150	[illegible]	189	240	[illegible]	[illegible]	219
22	[illegible]	210	[illegible]	10323	[illegible]	183	2678	127	185	[illegible]	185	[illegible]	[illegible]	49	224
23	[illegible]	250	209	10424	[illegible]	162	2679	182	187	[illegible]	222	212	10351	99	231
24	[illegible]	222	210	[illegible]	[illegible]	56	2678	85	35	10793	212	204	10529	70	226
25	[illegible]	[illegible]	212	10361	139	[illegible]	[illegible]	98	118	10772	[illegible]	[illegible]	10363	177	211
26	[illegible]	237	228	10428	141	178	2727	92	183	10431	209	206	10969	175	198
27	15132	[illegible]	264	[illegible]	158	[illegible]	2726	98	95	[illegible]	[illegible]	210	[illegible]	[illegible]	[illegible]
28	[illegible]	390	254	10276	153	162	2505	9	93	[illegible]	[illegible]	209	[illegible]	[illegible]	[illegible]
29	[illegible]	289	267	10299	156	169	2508	79	92	[illegible]	205	208	10878	212	189
1930	[illegible]	270	277	10334	132	[illegible]	2468	74	87	10102	180	206	10471	[illegible]	89
31	15868	186	266	10689	103	[illegible]	2478	[illegible]	82	10081	168	98	10596	184	[illegible]
32	[illegible]	183	241	10749	38	6	2473	38	75	10258	[illegible]	85	[illegible]	76	171
33	[illegible]	133	227	11001	25	95	2463	48	66	10199	40	49	10555	56	30
34	[illegible]	182	[illegible]	[illegible]	60	[illegible]	2435	85	65	[illegible]	110	[illegible]	[illegible]	134	18
1935	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2456	[illegible]	79	[illegible]	104	112	[illegible]	137	23
36	12854	218	[illegible]	10839	95	61	2488	[illegible]	80	9904	112	181	10579	[illegible]	117
37	[illegible]	137	[illegible]	10155	119	77	2395	63	[illegible]	9886	121	87	10286	[illegible]	131
38	[illegible]	126	170	9964	117	92	2376	57	[illegible]	[illegible]	106	111	[illegible]	[illegible]	143
39	13825	178	70	9816	120	[illegible]	2340	35	77	[illegible]	[illegible]	145	[illegible]	[illegible]	51
1940	13740	174	[illegible]	9290	109	[illegible]	2315	54	66	9881	163	123	[illegible]	[illegible]	101

Year	K C Sou Miles	K C Sou Ties	K C Sou 5 Yr Avg Ties	Lehigh Valley Miles	Lehigh Valley Ties	Lehigh Valley 5 Yr Avg Ties	Mich. Cent Miles	Mich. Cent Ties	Mich. Cent 5 Yr Avg Ties	MK&T Miles	MK&T Ties	MK&T 5 Yr Avg Ties	Monon CI&L Miles	Monon CI&L Ties	Monon CI&L 5 Yr Avg Ties
1911	246	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	285	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
12	[illegible]	294		[illegible]	[illegible]	[illegible]	[illegible]	208	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
13	26	351		[illegible]	[illegible]	89	3659	305	284	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	335	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	284	[illegible]	3939	[illegible]	346	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	402	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	289	338	[illegible]	3384	286	248	3884	[illegible]	290	4065	282	355	[illegible]	[illegible]	[illegible]
17	298	[illegible]	320	3438	[illegible]	258	3922	[illegible]	302	4080	235	322	[illegible]	[illegible]	[illegible]
18	290	231	305	[illegible]	[illegible]	212	3928	[illegible]	280	4140	149	295	[illegible]	[illegible]	[illegible]
19	298	273	288	3143	[illegible]	226	3974	144	232	4176	[illegible]	276	902	[illegible]	83
1920	301	290	274	3392	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	90	[illegible]	[illegible]
21	308	310	278	3401	133	159	[illegible]	[illegible]	[illegible]	4249	[illegible]	[illegible]	907	[illegible]	[illegible]
22	1303	249	272	3413	[illegible]	39	3868	[illegible]	169	4251	[illegible]	231	910	185	181
23	1324	227	278	3418	91	122	3866	206	[illegible]	425	[illegible]	225	[illegible]	[illegible]	131
24	325	225	260	[illegible]	109	105	3844	[illegible]	84	[illegible]	[illegible]	222	918	[illegible]	15
25	378	52	233	3424	91	100	[illegible]	[illegible]	194	4379	[illegible]	209	920	131	185
26	380	[illegible]	195	3438	82	98	3870	53	194	4319	[illegible]	204	[illegible]	[illegible]	[illegible]
27	[illegible]	38	[illegible]	[illegible]	100	85	3566	42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34
28	380	[illegible]	153	[illegible]	61	89	3558	[illegible]	42	4029	[illegible]	[illegible]	[illegible]	120	129
29	1329	52	141	[illegible]	52	75	3541	[illegible]	39	[illegible]	[illegible]	229	[illegible]	[illegible]	124
1930	1319	165	143	[illegible]	64	72	3540	94	[illegible]	4019	[illegible]	[illegible]	980	145	125
31	1322	[illegible]	68	[illegible]	33	66	[illegible]	[illegible]	168	4022	94	[illegible]	964	[illegible]	128
32	1268	65	[illegible]	3085	59	56	[illegible]	30	85	4135	[illegible]	165	933	64	128
33	[illegible]	21	166	[illegible]	53	59	3766	33	63	[illegible]	38	38	[illegible]	[illegible]	108
34	[illegible]	109	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	888	[illegible]	[illegible]
1935	1236	192	125	2978	61	53	[illegible]	72	58	4103	[illegible]	2	968	91	[illegible]
36	1260	[illegible]	119	2813	[illegible]	54	3360	103	[illegible]	[illegible]	[illegible]	[illegible]	792	132	87
37	[illegible]	[illegible]	[illegible]	2831	15	[illegible]	①			[illegible]	[illegible]	117	[illegible]	23	99
38	[illegible]	16	[illegible]	[illegible]	30	30	①			[illegible]	94	117	82	[illegible]	[illegible]
39	258	42	124	[illegible]	58	39	①			4093	[illegible]	[illegible]	801	[illegible]	135
1940	1255	33	132	2856	58	38	①			4078	75	95	793	97	[illegible]

Year	N.Y.C. (East) Miles	N.Y.C. (East) Ties	N.Y.C. (East) 5 Yr Avg Ties	N.Y.C. (West) Miles	N.Y.C. (West) Ties	N.Y.C. (West) 5 Yr Avg Ties	Nor Pacific Miles	Nor Pacific Ties	Nor Pacific 5 Yr Avg Ties	Penna. Miles	Penna. Ties	Penna. 5 Yr Avg Ties	Soo Line Miles	Soo Line Ties	Soo Line 5 Yr Avg Ties
1911	7535	229	[illegible]	4770	268	257	[illegible]	284	294	20085	[illegible]	[illegible]			
12	[illegible]	219	[illegible]	4909	265	258	[illegible]	[illegible]	282	[illegible]	290	[illegible]			
13	[illegible]	[illegible]	[illegible]	5013	[illegible]	264	[illegible]	[illegible]	293	20441	[illegible]	[illegible]	4708	272	
14	7800	[illegible]	245	3836	[illegible]	[illegible]	[illegible]	386	297	20578	292	[illegible]	4841	302	
15	8000	203	244	5010	301	273	9536	276	296	20686	314	278	4998	270	
16	8034	251	240	[illegible]	273	275	[illegible]	[illegible]	[illegible]	20829	[illegible]	289	5007	208	
17	8099	[illegible]	235	5069	278	276	9709	292	288	22526	[illegible]	[illegible]	5025	248	[illegible]
18	8248	[illegible]	222	5131	249	247	[illegible]	230	210	23003	[illegible]	258	2947	218	247
19	8288	[illegible]	[illegible]	5175	189	256	[illegible]	220	253	23560	[illegible]	[illegible]	5081	284	[illegible]
1920	8290	[illegible]	[illegible]	5185	[illegible]	233	[illegible]	[illegible]	245	22083	202	217	5081	[illegible]	[illegible]
21	8377	[illegible]	196	5188	[illegible]	217	[illegible]	231	247	[illegible]	232	206	5214	360	288
22	8471	139	96	5194	[illegible]	203	[illegible]	[illegible]	215	[illegible]	232	210	5226	317	[illegible]
23	8399	[illegible]	91	5209	[illegible]	82	9798	[illegible]	[illegible]	[illegible]	211	[illegible]	5235	340	320
24	8237	[illegible]	193	5367	129	170	[illegible]	163	[illegible]	23348	[illegible]	211	5226	358	335
25	8150	[illegible]	194	5368	110	138	9748	[illegible]	[illegible]	23800	207	212	5256	339	[illegible]
26	[illegible]	170	[illegible]	5372	91	135	9729	[illegible]	144	[illegible]	204	206	5256	310	[illegible]
27	8143	[illegible]	[illegible]	5321	84	18	[illegible]	136	150	[illegible]	[illegible]	196	5256	260	[illegible]
28	8430	[illegible]	164	5317	89	102	10035	[illegible]	155	24111	146	187	5264	279	[illegible]
29	[illegible]	[illegible]	155	5343	74	91	10861	[illegible]	53	23975	153	183	5276	236	[illegible]
1930	8393	[illegible]	144	5369	66	81	[illegible]	[illegible]	[illegible]	24965	[illegible]	165	5193	222	[illegible]
31	[illegible]	96	130	5838	31	75	9168	103	132	23951	[illegible]	139	5169	173	224
32	7893	50	108	5429	40	65	9177	101	135	23924	46	112	5136	164	211
33	[illegible]	57	97	5765	40	55	9150	96	112	23925	50	89	5092	[illegible]	193
34	[illegible]	[illegible]	77	6101	65	[illegible]	[illegible]	[illegible]	101	23751	55	[illegible]	5064	158	[illegible]
1935	7798	[illegible]	[illegible]	6076	65	53	9168	91	95	23570	55	56	5032	139	189
36	760	75	[illegible]	5980	85	59	9090	122	98	23418	71	55	5971	179	178
37	①			①			9987	119	106	[illegible]	[illegible]	65	5000	[illegible]	171
38	①			①			9074	128	110	22572	53	66	4982	161	169
39	①			①			9058	130	121	22451	71	69	4957	133	[illegible]
1940	①			①			8985	133	130	22343	77	74	[illegible]	138	[illegible]

Year	Southern Pac (Atlantic Syst) Miles	Ties	5 Yr Avg Ties	Southern Pac (Pacific Syst) Miles	Ties	5 Yr Avg Ties	Union Pacific Miles	Ties	5 Yr Avg Ties	C R R of N J Miles	Ties	5 Yr Avg Ties	Reading Miles	Ties	5 Yr Avg Ties
1911	4508	257	[illegible]	9867	[illegible]	245	5291	[illegible]	[illegible]	69	[illegible]	231	2939	290	
12	4519	299	[illegible]	9487	225	250	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	3007	[illegible]	
13	4356	[illegible]	[illegible]	9236	[illegible]	225	[illegible]	[illegible]	[illegible]	364	[illegible]	[illegible]	3012	[illegible]	
14	[illegible]	295	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	248	[illegible]	[illegible]	[illegible]	[illegible]	3041	[illegible]	
15	4634	384	[illegible]	9354	[illegible]	231	3893	238	[illegible]	1533	[illegible]	[illegible]	1360	248	290
16	[illegible]	367	313	10103	[illegible]	231	[illegible]	[illegible]	[illegible]	645	56	[illegible]	3388	92	[illegible]
17	4006	[illegible]	303	10368	88	212	3813	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3424	[illegible]	280
18	4279	218	[illegible]	10434	244	223	5934	[illegible]	223	[illegible]	[illegible]	[illegible]	3463	164	219
19	4885	267	285	10356	235	212	[illegible]	185	[illegible]	[illegible]	132	[illegible]	3474	[illegible]	[illegible]
1920	4339	289	[illegible]	10492	[illegible]	[illegible]	6035	206	[illegible]	1199	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	4992	331	[illegible]	10506	285	239	6038	[illegible]	[illegible]	1739	31	136	3683	169	158
22	4999	[illegible]	[illegible]	10563	[illegible]	244	6167	202	[illegible]	1743	142	139	3494	160	159
23	4988	298	332	10777	[illegible]	238	6227	195	[illegible]	[illegible]	16	137	3497	180	[illegible]
24	5813	255	337	12859	206	229	6232	215	201	[illegible]	133	[illegible]	3495	[illegible]	[illegible]
25	6016	238	301	12934	244	225	6235	214	202	[illegible]	115	137	3500	[illegible]	181
26	6077	217	[illegible]	13400	246	225	[illegible]	209	[illegible]	[illegible]	85	[illegible]	3500	190	186
27	5921	222	231	12479	[illegible]	217	[illegible]	[illegible]	[illegible]	[illegible]	68	123	3525	[illegible]	[illegible]
28	5989	138	248	12544	[illegible]	[illegible]	5909	194	206	[illegible]	83	97	3513	130	[illegible]
29	5812	223	231	12839	206	226	5902	161	195	1329	79	86	[illegible]	135	161
1930	5821	[illegible]	238	12905	64	[illegible]	5959	[illegible]	177	1527	83	85	3506	121	140
31	5983	100	203	12860	[illegible]	88	5932	106	136	1524	[illegible]	79	3591	96	128
32	5899	99	175	12893	37	163	6012	85	133	1531	72	[illegible]	3528	22	[illegible]
33	5818	87	163	12893	57	133	6012	86	112	1522	45	[illegible]	3270	24	[illegible]
34	5787	111	128	12570	88	107	[illegible]	[illegible]	105	1578	32	63	3296	31	59
1935	5725	66	103	12519	66	88	5796	155	111	1582	49	59	3296	33	41
36	5783	22	99	12446	85	77	5823	[illegible]	127	1591	[illegible]	52	3293	37	[illegible]
37	5785	132	106	12397	95	76	5835	208	132	[illegible]	82	50	3058	40	33
38	5683	132	113	12363	99	85	5851	183	172	1691	40	49	3050	27	36
39	5655	134	117	12279	96	80	5854	[illegible]	187	1587	78	[illegible]	3045	42	36
1940	5637	143	[illegible]	12262	102	95	②			1482	90	[illegible]	3018	50	40

Year	Boston & Maine Miles	Ties	5 Yr Avg Ties	C & O Miles	Ties	5 Yr Avg Ties	New York Central Miles	Ties	5 Yr Avg Ties	Union Pacific Miles	Ties	5 Yr Avg Ties	Miles	Ties	5 Yr Avg Ties	Totals for All Roads Miles	No. of Roads	Ties per Mile	5 Yr Avg Ties
1911																136129	22	262	[illegible]
12	3953	231														[illegible]	24	241	[illegible]
13	3482	[illegible]														[illegible]	25	239	[illegible]
14	3643	482														[illegible]	24	[illegible]	251
15	[illegible]	357														[illegible]	24	255	[illegible]
16	3863	[illegible]	[illegible]													182942	25	249	254
17	3863	230	[illegible]	3740	392											190485	27	206	[illegible]
18	3822	254	327	3777	304											192773	27	193	234
19	3853	[illegible]	267	3855	284											[illegible]	27	203	223
1920	[illegible]	[illegible]	[illegible]	3914	289											196085	27	219	212
21	3889	304	[illegible]	3951	[illegible]	[illegible]										[illegible]	27	[illegible]	235
22	3829	255	238	3798	309	288										197297	27	237	204
23	3832	270	[illegible]	[illegible]	[illegible]	304										[illegible]	27	198	205
24	3777	359	[illegible]	4067	288	285										201076	27	182	[illegible]
25	3744	[illegible]	[illegible]	[illegible]	[illegible]	293										203330	27	188	196
26	[illegible]	[illegible]	274	4390	276	293										204458	27	[illegible]	[illegible]
27	3544	183	272	[illegible]	252	282										198312	27	185	187
28	3533	292	[illegible]	4603	[illegible]	278										198981	27	184	[illegible]
29	3535	270	[illegible]	4603	[illegible]	249										203288	27	176	183
1930	3537	248	[illegible]	[illegible]	[illegible]	[illegible]										201414	27	152	176
31	3575	157	252	5273	138	194										199817	27	114	163
32	3509	67	208	5395	77	[illegible]										201242	27	83	143
33	3584	75	65	5193	92	35										201738	27	73	120
34	[illegible]	109	[illegible]	5290	96	[illegible]										[illegible]	27	95	104
1935	3642	[illegible]	[illegible]	5216	72	95										198304	27	95	93
36	3514	71	[illegible]	5217	91	86		82	85		159					197825	27	113	92
37	3278	113	87	5117	66	83	22217	[illegible]	76		178					196177	27	[illegible]	[illegible]
38	3220	73	86	5220	83	82	22081	[illegible]	81		150					194873	27	106	[illegible]
39	3093	69	[illegible]	5187	81	79	[illegible]	94	85		155					193594	27	115	104
1940	3016	91	65	5211	74	79	21574	99	91	13148	40	[illegible]				200019	27	118	112

[illegible]	AT&SF	B&O	CB&Q	C&EI	CCC&StL	CMStP&P	CRI&P	DL&W	Gt Northern	Ill's Central	K C Sou	Lehigh Valley	Mich. Cent	MK&T	Monon CI&L	N.Y.C. (East)	N.Y.C. (West)	Nor Pacific	Penna.	Soo Line	S.P. (Atlantic)	S.P. (Pacific)	Union Pacific	C R R of N J	Reading	Boston & Maine	C & O	New York Central	Union Pacific
[illegible]		1917		1907	1908	1916	1910	1913	1922		1914	1914	1913	1904	1910		1915	1913	1920	1929	1910		1906			1927	1922		
[illegible]	2820	2831	3290	3181	2878	2850	2828	2890	3115	3062	2938	2785	2873	2920	3040	2976	2935	3000	2700	2943	2978	2936	2805	2815	2854	2870	2803		
1935	98	93	100	89	100	88	100	100	95	73	100	100	100	[illegible]	[illegible]	100	99	91	90	56	95	87	100	100	100	87	100		
36	62	99	100	86	100	79	100	100	93	81	100	100	100	[illegible]	[illegible]	94	99	96	100	55	98	87	100	100	100	88	100		
37	98	99	99	90		62	100	100	99	88	100	100		[illegible]	[illegible]			97	100	41	100	89	100	100	98	95	100	100	
38	100	90	100	100		62	100	100	92	87	100	100		98	98			98	100	25	100	87	100	100	98	87	99	100	
39	90	93	100	100		80	100	100	94	97	100	100		[illegible]	100			95	100	38	98	87	100	82	94	85	100	100	
1940	82	92	86	100		81	100	100	94	92	100	100		98	99			99	100	41	100	87		100	94	84	102	102	97
1930	[illegible]	89	105	100	98	63	93	99	49	● 85	[illegible]	85		93		82	93	75	77	26	52	63	85	97	84	42	75		
31	98	91	109	100	93	67	93	95	52	● 87	80	85		94	95	84	96	79	79	30	55	64	87	97	90	47	79		
32	99	98	100	102	96	70	97	97	54	● 87	83	87	82	92	96	80	94	82	80	32	56	64	90	97	92	49	81		
33	99	88	82	100	96	71	98	97	55		84	95	82	90	95	84	92	85	81	36	57	65	92	97	92	51	84		
34	90	88	100	100	92	67	98	97	58		86	96	85	97	[illegible]	[illegible]	94	85	83	40	58	65	92	97	92	55	87		
1935	99	89	100	100	99	73	98	98	61		87	96	84	89	[illegible]	[illegible]	97	89	85	43	59	66	93	97	93	59	89		
36	100	85	80	90	99	78	98	98	65	89	89	97	84	89	[illegible]		94	90	87	48	60	67	93	97	93	61	91		
37	100	92	78	100		76	98	98	67	89	90	96		89	98			91	90	48	61	67	93	97	94	65	94	94	
38	100	90	100	100		77	98	98	70	89	92	98		94	100			95	92	49	63	68	97	97	96	69	96	95	
39	100	88	103	90		78	98	99	73	64	92	98		96	99			96	94	51	64	69	94	97	95	74	96	93	
1940	102	8	103	93		80	99	98	76	92	93	[illegible]		96	[illegible]			98	94	53	65	70		97	95	77	97	94	95

● Main Line Only

① – Included in New York Central

② See continued Union Pacific record.

WOOD PRESERVING PLANT PRACTICE

Locate seasoning yards where there is maximum exposure to the sun and to freely-circulating air. Avoid low, humid situations. Arrange for effective drainage and keep the yard free of vegetation and debris, especially decaying wood.

Support all stacks of seasoning material on treated or other non-decaying sills, with at least 12 inches of unenclosed air space beneath the lowest layer of material, but more space in warm humid localities.

Promote air circulation by providing between the stacks of material, in continuous lines across the seasoning yard, alleys not less than 3 feet wide in working spaces and 1 foot wide elsewhere, giving consideration to the direction of the prevailing wind.

Open stacking furthers the drying of wood, but the spacing of the pieces depends on their size and the mean relative humidity and temperature of the locality. In most sections satisfactory seasoning is accomplished by stacking cross-ties in layers of 8 to 10 with one tie as a stringer at every other end; timbers 5 inches and thicker with at least 2 inches between layers; lumber less than 5 inches thick with at least 1 inch between layers, round material with at least 1 inch between layers. Within each layer the pieces should be at least 2 inches apart.

Stickers of preserved wood or areas of contact brushed with preservatives will reduce the likelihood of the decay called "stackburn."

The length of time required to air-dry wood in preparation for its preservative treatment varies with the kind, dimensions, moisture content when stacked, and climatic and site conditions; consequently a specific seasoning period must be determined for each particular locality, and care taken to assure the treatment of all material before it starts to decay.

Records such as provided for by Form 1700 on AREA Manual pages 17–63, 64 will supply data of value in determining the most effective preserving procedures.

Report on Assignment 2

Service Test Records for Treated Ties

A. J. Loom (chairman, subcommittee), G. B. Campbell, W. R. Goodwin, L. B. Holt, R. S. Hubley, R. P. Hughes, M. F. Jaeger, T. H. Strate, W. A. Summerhays.

This report is presented as information.

The table of tie renewals per mile maintained on various roads has been revised to include data for 1940.

Reports of special test tracks are submitted for the following roads:

Chicago, Burlington & Quincy
Chicago, Milwaukee, St. Paul & Pacific
Chicago & North Western
Northern Pacific

(Inspection reports for 1941 are submitted by the U. S. Forest Products Laboratory covering the Hartford, Fair Grounds and University Avenue test tracks of the Chicago, Milwaukee, St. Paul & Pacific.)

Report of Thirty-first Annual Inspection of Chicago, Burlington & Quincy Experimental Ties

The results of the 1940 inspection of the experimental ties in the tracks of the Chicago, Burlington & Quincy are given in the accompanying tabulations. These ties were laid in 1909 and 1910, some treated with coal-tar creosote by the full-cell process, with 10 to 12 lb. per cu. ft.; some with zinc chloride (Burnett process) with ½ lb. per cu. ft.; some with a mixture of these two preservatives (Card process), with an absorption of ½ lb. of zinc chloride and 3 lb. of creosote per cu. ft.; and some were untreated:

Average Life of Untreated Ties in Years

Kind	Total placed	Average years
Ash	116	5.1
Beech	208	5.0
Red birch	217	3.6
Chestnut	259	9.7
Cottonwood	86	2.9
Cypress	225	8.3
White elm	191	5.3
Hemlock	190	4.9
Hickory	110	5.5
Loblolly pine	248	5.3
Hard maple	122	4.7
Soft maple	125	3.6
White oak	125	11.1
Red oak	204	5.3
Pin oak	126	6.3
Poplar	126	5.3
Red gum	152	4.1
Sycamore	131	3.3
Tamarack	175	5.1
Tupelo gum	136	3.5
Total placed	3272	5.6

1940 Inspection of Cross Tie Test Track, C. B. & Q.—Results of 31 Years Service

Process	Lines East						Lines West					
	Total placed	Total removed to date	Per cent removed account decay	Per cent removed account other causes	Estimated years average life	Actual years average life to date	Total placed	Total removed to date	Per cent removed account decay	Per cent removed account other causes	Estimated years average life	Actual years average life to date
Ash												
Creosote	19	19	32	68	------	16.7	15	15	20	80	------	20.7
Card	289	283	21	77	------	18.9	103	98	22	74	------	18.3
Burnett	16	16	44	56	------	18.3	15	15	47	53	------	17.2
Untreated	70	70	99	1	------	5.1	46	46	100	------	------	5.3
Beech												
Creosote	321	166	16	36	33.5	27.2	163	76	12	35	35.	25.9
Card	807	827	47	56	------	17.7	418	409	42	55	------	17.3
Burnett	210	209	56	43	------	16.0	105	105	60	40	------	15.8
Untreated	134	134	98	2	------	4.6	74	74	93	7	------	5.4
Birch												
Creosote	75	74	72	27	------	22.9	59	45	15	61	28.	23.
Card	715	699	42	55	------	18.2	360	350	36	61	------	18.
Burnett	73	73	48	52	------	13.0	30	30	43	57	------	14.4
Untreated	139	139	99	1	------	3.6	78	78	100	------	------	3.6
Chestnut												
Creosote	------	------	------	------	------	------	------	------	------	------	------	------
Card	164	164	18	82	------	10.1	89	89	9	91	------	10.2
Burnett	------	------	------	------	------	------	------	------	------	------	------	------
Untreated	169	169	28	72	------	9.4	90	90	22	78	------	10.2
Cottonwood												
Creosote	88	52	10	48	32.5	26.1	45	18	16	24	37.	25.3
Card	296	264	33	55	26.	19.9	160	147	28	64	------	18.2
Burnett	------	------	------	------	------	------	------	------	------	------	------	------
Untreated	56	56	95	5	------	2.6	30	30	100	------	------	3.5
Cypress												
Creosote	25	21	8	76	26.5	26.5	29	28	41	55	------	20.5
Card	409	381	13	80	------	19.7	254	245	25	71	------	18.6
Burnett	25	25	12	88	------	21.6	30	30	50	50	------	14.7
Untreated	135	135	79	21	------	8.8	90	90	89	11	------	7.5

1940 Inspection of Cross Tie Test Track, C. B. & Q.—Results of 31 Years Service (Continued)

Process	Lines East						Lines West					
	Total placed	Total removed to date	Per cent removed account decay	Per cent removed account other causes	Estimated years average life	Actual years average life to date	Total placed	Total removed to date	Per cent removed account decay	Per cent removed account other causes	Estimated years average life	Actual years average life to date
Elm												
Creosote	208	156	36	39	28.5	24.8	119	58	12	39	34.	25.7
Card	594	533	32	58	25.	21.8	371	323	33	54	26.	20.9
Burnett	224	221	50	48	------	18.9	73	73	63	37	------	16.1
Untreated	113	113	91	9	------	4.8	78	78	96	4	------	5.9
Hemlock												
Creosote	136	127	33	61	------	20.1	99	89	24	66	25.	19.
Card	816	793	30	66	------	18.4	488	471	39	56	------	16.
Burnett	125	125	48	52	------	17.3	87	86	41	57	------	15.6
Untreated	112	112	100	------	------	4.7	78	78	99	1	------	5.3
Hickory												
Creosote	10	8	20	60	27.5	25.2	15	14	13	80	------	22.
Card	185	184	32	67	------	16.3	105	102	43	54	------	16.0
Burnett	9	8	22	67	25.	21.7	15	15	53	47	------	17.3
Untreated	65	65	89	11	------	5.5	45	45	100	------	------	5.5
Pine—Loblolly Sap												
Creosote	145	109	12	63	28.5	24.4	72	57	19	60	27.5	19.2
Card	949	885	31	62	------	19.7	386	373	27	70	------	15.9
Burnett	128	128	74	26	------	12.4	72	72	46	54	------	12.0
Untreated	157	157	99	1	------	5.5	91	91	100	------	------	4.8
Hard Maple												
Creosote	82	71	56	30	26.	24.7	34	24	18	53	29.5	23.4
Card	560	498	46	43	25.5	20.9	272	255	37	57	------	19.3
Burnett	50	50	52	48	------	19.6	15	15	87	13	------	16.7
Untreated	77	77	98	2	------	4.3	45	45	100	------	------	5.3
Soft Maple												
Creosote	139	134	51	45	------	19.8	63	46	33	42	28.5	22.6
Card	462	435	51	43	------	17.3	264	238	32	58	25.	19.0
Burnett	125	125	64	36	------	13.4	57	57	39	61	------	13.6
Untreated	82	82	99	1	------	3.4	43	43	95	5	------	4.0

White Oak												
Creosote	25	18	16	56	28.5	27.2	15	14	27	67	------	19.6
Card	234	233	39	60	------	17.2	152	152	31	69	------	17.1
Burnett	28	28	60	40	------	17.4	15	15	40	60	------	15.3
Untreated	81	81	88	12	------	10.8	44	44	81	19	------	11.7
Red Oak												
Creosote	165	120	10	63	29.	25.6	120	99	14	69	27.	22.9
Card	776	744	27	68	------	20.1	510	506	35	64	------	17.4
Burnett	158	158	56	44	------	17.2	116	115	47	52	------	15.3
Untreated	129	129	96	4	------	5.1	75	75	93	7	------	5.7
Pin Oak												
Creosote	189	124	8	58	30.5	26.5	133	95	14	60	29.	25.6
Card	512	477	27	66	------	21.8	321	315	27	71	------	19.9
Burnett	23	21	57	35	------	22.6	44	44	32	68	------	16.0
Untreated	81	81	96	4	------	6.4	45	45	98	2	------	6.2
Poplar												
Creosote	50	39	18	60	27.5	24.	30	27	17	73	25.	17.5
Card	396	392	44	54	------	15.5	253	246	44	53	------	15.5
Burnett	50	50	44	56	------	14.3	30	30	57	43	------	13.0
Untreated	81	81	94	6	------	5.1	45	45	96	4	------	5.6
Red Gum												
Creosote	89	69	36	42	27.5	21.2	48	33	27	42	30.	19.8
Card	429	388	44	46	25.	19.4	233	193	46	36	27.	20.4
Burnett	75	75	67	33	------	11.6	43	43	74	26	------	12.4
Untreated	98	98	97	3	------	3.8	54	54	98	2	------	4.6
Sycamore												
Creosote	75	49	39	27	30.5	24.7	15	4	------	27	42.	27.6
Card	399	355	53	35	25.5	20.	121	117	66	31	------	14.9
Burnett	75	75	71	29	------	13.7	15	15	80	20	------	13.5
Untreated	81	81	98	2	------	2.9	50	50	96	4	------	3.9
Tamarack												
Creosote	106	98	15	77	------	21.7	108	91	15	69	26.5	19.4
Card	813	810	22	77	------	18.1	494	469	33	62	------	17.7
Burnett	108	108	44	56	------	18.1	107	106	32	67	------	16.0
Untreated	98	98	96	4	------	4.9	77	77	99	1	------	5.3
Tupelo Gum												
Creosote	99	79	28	51	27.5	22.7	54	37	24	44	30.	21.4
Card	436	335	27	51	27.5	23.0	237	147	32	30	31.5	25.4
Burnett	76	75	47	52	------	15.2	41	41	61	39	------	14.0
Untreated	88	88	98	2	------	3.0	48	48	98	2	------	4.4

SUMMARY OF 1940 INSPECTION OF CROSS TIE TEST TRACKS, C. B. & Q. R. R.—RESULTS OF 31 YEARS SERVICE

	Lines East						Lines West					
Process	Total placed	Total removed to date	Per cent removed account decay	Per cent removed other causes	Actual average years life to date	Forest Products Lab. curve estimated yrs. average life	Total placed	Total removed to date	Per cent removed account decay	Per cent removed other causes	Actual average years life to date	Forest Products Lab. curve estimated yrs. average life
Straight creosote	2, 046	1, 538	26	49	24. 2	28. 5	1, 236	871	17	53	22. 7	29. 5
Card	10, 241	9, 680	35	60	19. 1	------	5, 591	5, 244	35	59	18.	------
Burnett	1, 578	1, 571	55	44	16. 1	------	910	907	49	50	15. 0	------
Untreated	2, 046	2, 046	90	10	5. 4	------	1, 226	1, 226	91	9	5. 8	------
Total treated	13, 865	12, 789	36	57	19. 5	------	7, 737	7, 022	34	57	18. 4	------
Grand total	15, 911	14, 835	------	------	------	------	8, 963	8, 248	------	------	------	------

Note: These percentages include only the ties placed in what are termed the thousand-tie lots on the various divisions.

CONDITION OF EXPERIMENTAL TIES IN THE CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC RAILROAD TEST TRACK NEAR HARTFORD, WIS., AFTER ABOUT 30 YEARS SERVICE

Ties set October 1911

Preservatives	Process	Tie plates	Average absorption	Ties in test	Condition of ties—May, 1941						Average life
					Serviceable		Removed				
							Mainly for decay		Mainly for causes other than decay[a] and unknown causes[b]		
			lb. per cu. ft.	No.	Number	Per cent	Number	Per cent	Number	Per cent	years
Chestnut											
Zinc chloride	Burnett[c]	Flat	.50	10	----------		5	50.0	5	50.0	15.6
Zinc chloride	Burnett[c]	Ribbed	.50	13	----------		6	46.1	7	53.9	13.4
Spruce											
Mercuric chloride	Kyan	Flat	--[d]	13	3	23.1	9	69.2	1	7.7	24.9[h]
Mercuric chloride	Kyan	None	--[d]	12	2	16.7	8	66.6	2	16.7	21.4[h]
Maple											
Creosote	Full cell	None	10.7	50	50	100.0	----------				
Creosote	Full cell	Flat	12.2	49	49	100.0	----------				
Creosote	Rueping	Flat	5.0	50	49	98.0	1	2.0	----------		
Creosote	Rueping	None	4.8	50	50	100.0	----------				
20% creosote, 80% zinc chloride	Card	None	14.7[f]	50	46	92.0	3	6.0	1	2.0	--------
20% creosote, 80% zinc chloride	Card	Flat	17.3[f]	50	47	94.0	2	4.0	1	2.0	--------
Semi-refined paraffin oil	Full cell	Flat	11.1	50	44	88.0	3	6.0	3	6.0	45.0[e]
Semi-refined paraffin oil	Full cell	None	14.3	49	45	91.8	2	4.1	2	4.1	--------
Zinc chloride-creosote	Two movement	Flat	16.4[g]	50	37	74.0	8	16.0	5	10.0	38.0[e]
Zinc chloride-creosote	Two movement	None	15.1[g]	50	21	42.0	26	52.0	3	6.0	30.0[e]
Zinc chloride	Burnett	None	.50	49	1	2.0	26	53.1	22	44.9	19.0[h]
Zinc chloride	Burnett	Flat	.50	50	19	38.0	22	44.0	9	18.0	30.0[e]
Untreated		None	----------	50	----------		50	100.0	----------		6.4
Untreated		Flat	----------	50	----------		50	100.0	----------		7.8

CONDITION OF EXPERIMENTAL TIES IN THE CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC RAILROAD TEST TRACK NEAR HARTFORD, WIS., AFTER ABOUT 30 YEARS SERVICE—Continued

Ties Set October 1911

Preservatives	Process	Tie plates	Average absorption	Ties in test	Condition of ties—May 1941						Average life
					Serviceable		Removed				
							Mainly for decay		Mainly for causes other than decay[a] and unknown causes[b]		
			lb. per cu. ft.	No.	Number	Per cent	Number	Per cent	Number	Per cent	years
			Red Oak								
Creosote	Full cell	None	11.2	52	51	98.1	----------		1	1.9	--------
Creosote	Full cell	Flat	10.9	50	48	96.0	----------		2	4.0	--------
Creosote	Rueping	Flat	5.0	50	48	96.0	1	2.0	1	2.0	--------
Creosote	Rueping	None	5.7	50	47	94.0	2	4.0	1	2.0	--------
20% creosote, 80% zinc chloride	Card	None	15.5[f]	50	38	76.0	4	8.0	8	16.0	39.0[e]
20% creosote, 80% zinc chloride	Card	Flat	15.2[f]	50	50	100.0	----------				
Semi-refined paraffin oil	Full cell	Flat	8.4	50	44	88.0	5	10.0	1	2.0	45.0[e]
Seni-refined paraffin oil	Full cell	None	6.2	49	29	59.2	11	22.4	9	18.4	33.0[e]
Zinc chloride-creosote	Two movement	Flat	14.7[g]	50	35	70.0	9	18.0	6	12.0	37.0[e]
Zinc chloride-creosote	Two movement	None	16.0[g]	50	27	54.0	16	32.0	7	14.0	33.0[e]
Zinc chloride	Burnett[c]	Flat	.50	206	4	1.9	136	66.1	66	32.0	19.0[b]
Zinc chloride	Burnett[c]	Ribbed	.50	53	2	3.8	32	60.4	19	35.8	20.4[h]
Zinc chloride	Burnett	None	.47	50	8	16.0	32	64.0	10	20.0	25.0[e]
Zinc chloride	Burnett	Flat	.49	50	30	60.0	13	26.0	7	14.0	34.0[e]
Untreated		None	----------	50	----------		50	100.0	----------		8.7
Untreated		Flat	----------	50	----------		50	100.0	----------		9.2

Note: This test is being conducted in cooperation with the U. S. Forest Products Laboratory.

[a] Rail cutting, splitting, etc.

[b] Ties not available for examination after removal to determine the cause of removal.

[c] Obtained from regular stock of C. M. St. P. & P. Ry.

[d] Steeping treatment in cold mercuric chloride solution—absorption figures not available.

[e] Estimate—Based on U. S. Forest Products Laboratory tie renewal curve.

[f] Emulsion of 80 parts of 3% zinc chloride solution and 20 parts of creosote by volume at approximately 70 deg. F

[g] 3% zinc chloride solution plus creosote. Treatment consisted of bath in hot creosote for 30 minutes at atmospheric pressure followed by pressure treatment with 3% zinc chloride solution.

[h] An additional life of 2 years was estimated for each remaining tie in arriving at this value.

Report of Test Ties in C. M. St. P. & P. Tracks in Addition to Those Carried in Conjunction With the United States Forest Products Laboratory—1940 Inspection

Species	Location	Grade	Treatment	Absorption lb. cu.ft.	Year placed	Total placed	Ballast	Years service	Total removed	Removed account decay	Removed other causes
Hemlock	Darien, Wis.	No. 2 & 3 pole	Zinc chloride	. 52	1928	999	Good gravel	12	2	2	----
Soft maple	St. Louis Pk., Minn.	No. 2 & 3 sq. sawed & pole	Zinc chloride	. 50	1927	503	Good gravel	13	3	3	----
Hard maple (incised)	Watertown, Wis.	No. 4 square sawed	50-50 creo. and oil	8. 00	1935	400	Good Gravel	5	------	----	----

CONDITION OF THE EXPERIMENTAL TIES IN THE UNIVERSITY AVENUE TEST TRACK OF THE CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC RAILROAD AT MADISON, WIS., AT AN INSPECTION IN SEPTEMBER, 1941

Preservative	Treating method[a]	Species	Form[b] of ties	Average absorption of preservative Lbs. per cu. ft.	Ties in test	Serviceable		Removed				Not inspected (under crossings)		Missing or eliminated
								Mainly for decay		Causes other than decay[c] and unknown causes				
					No.	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Ties set 1922—19 years service														
Aczol	F	Red oak	S	16.38[d]	95	----------		90	94.7	----------		5	5.3	3
Zinc chloride (high iron content)	F	Red oak	S	.58[e]	87	6	6.9	33	37.9	48	55.2	----------		----------
Ties set 1923—18 years service														
25% low temp. c. t. distillate 75% mid continent oil	F	Red oak	H	8.22	100[f]	94	94.0	4	4.0	----------		2	2.0	--------
50% low temp. c. t. distillate 50% mid continent oil	F	Red oak	H	9.24	98[g]	91	92.9	3	3.1	2	2.0	2	2.0	1
Ties set 1924—17 years service														
C. T. creosote, grade 1[h]	F	Red oak	H–S	14.60	16	14	87.4	----------		1	6.3	1	6.3	--------
Low temp. c. t. distillate	F	Red oak	H–S	8.94	86	74	86.0	3	3.5	8	9.3	1	1.2	--------
10% low temp. c. t. distillate, 90% topped California oil	F	Red oak	H–S	8.94	99	90	90.9	2	2.0	6	6.1	1	1.0	--------
25% low temp. c. t. distillate, 75% topped California oil	F	Red oak	H–S	8.28	100	81	81.0	11	11.0	7	7.0	1	1.0	--------
Ties set 1925—16 years service														
Basilit	F	Red oak	H–S	.28[e]	49	42	85.7	3	6.1	4	8.2	----------		----------
10% c. t. creosote, grade 1[h], 90% petroleum	F	E. hemlock	S	10.26	87	74	85.1	4	4.6	9	10.3	----------		----------
50% c. t. creosote, grade 1[h], 50% petroleum	F	E. hemlock	S	11.91	82	75	91.5	2	2.4	5	6.1	----------		2
Sodium fluoride	F	Red oak	H–S	.52[e]	50	41	82.0	4	8.0	5	10.0	----------		----------
Sodium fluoride	F	Red oak	H–S	.26[e]	50	36	72.0	5	10.0	9	18.0	----------		----------
Triolith	F	Red oak	H–S	.25[e]	50	42	84.0	2	4.0	6	12.0	----------		----------
Zinc chloride	F	Red oak	H–S	.52[e]	50	24	48.0	19	38.0	7	14.0	----------		----------
Zinc chloride	F	Red oak	H–S	.26[e]	50	28	56.0	16	32.0	6	12.0	----------		----------
Zinc chloride—	E	Red oak	H	.34[e]	49	31	63.3	11	22.4	7	14.3	----------		----------
Petroleum emulsion				4.87[i]										
Zinc chloride—	E	So. yel. pine	H	.69[e]	42	34	80.9	1	2.4	7	16.7	----------		----------
Petroleum emulsion				9.21[i]										

Ties set 1925—16 years service—Continued														
Zinc chloride—	E	So. yel. pine	H	.39[e]	49	48	98.0	----------		1	2.0	----------		
Petroleum emulsion				7.92[i]										
Zinc chloride—	E	So. yel. pine	H	.27[e]	47	43	91.5	1	2.1	3	6.4	----------		
Petroleum emulsion				9.34[i]										
Ties set 1926—15 years service														
Basilit	F	Red oak	H-S	.52[e]	49	40	81.6	5	10.2	4	8.2	----------		
Basilit	F	E. hemlock	S	.18[e]	44	27	61.4	3	6.8	13	29.5	1	2.3	2
Sodium fluoride	F	E. hemlock	S	.17[e]	49	22	44.9	10	20.4	17	34.7	----------		
Triolith	F	Red oak	H-S	.56[e]	50	42	84.0	4	8.0	4	8.0	----------		
Triolith	F	E. hemlock	S	.18[e]	48	30	62.5	4	8.3	14	29.2	----------		
Ties set 1927—14 years service														
Borax	F	Red oak	H-S	.59	99	92	93.0	3	3.0	3.	3.0	1	1.0	1
Borax	F	Red oak	H-S	.24[j]	100	87	87.0	5	5.0	8	8.0	----------		
Zinc chloride	F	E. hemlock	S	.62[e]	112	78	69.6	2	1.8	32	28.6	----------		2
Zinc chloride	F	Yel. birch	S	.67[e]	129	68	52.7	33	25.6	28	21.7	----------		4
Zinc chloride	F	Corkbark fir	H-S	.45[e]	80	39	48.7	3	3.8	38	47.5	----------		
C. t. creosote, grade 1[h]	F, E	Corkbark fir	H-S	10.11	40	29	72.5	----------		11	27.5	----------		
Ties set 1925 to 1927—14 to 16 years service														
C. t. creosote, grade 1[h]	F	E. hemlock	S	15.51	284	248	87.3	4	1.4	28	9.9	4	1.4	6
Ties set 1928—13 years service														
Arsenious acid	F	Red oak	S	.47[k]	95	88	92.6	1	1.1	6	6.3	----------		
Arsenious acid	F	Red oak	S	.27[k]	99	92	93.0	2	2.0	5	5.0	----------		1
C. t. creosote, grade 1[h]	F	Yel. birch	S	21.43	21	20	95.2	----------		1	4.8	----------		
Sodium dichromate	F	Red oak	H-S	.52[m]	96	3	3.1	86	89.6	6	6.3	1	1.0	2
Sodium dichromate	F	Red oak	H-S	.27[m]	87[n]	----------		82	94.3	5	5.7	----------		2
Zinc-meta-arsenite	F	Red oak	S	.50[o]	97	93	95.9	1	1.0	3	3.1	----------		2
Zinc-meta-arsenite	F	Red oak	S	.26[o]	111	103	92.8	3	2.7	3	2.7	2	1.8	3
Ties set 1929—12 years service														
C. t. creosote, grade 1[h]	E	Engl. spruce	H	6.67	49	47	96.0	1	2.0	----------		1	2.0	3
Natural brine	F	E. hemlock	S	16.70[p]	197	59	30.0	111	56.3	27	13.7	----------		2
Nickel chromate	F	Red oak	S	.50[q]	97	22	22.7	73	75.3	1	1.0	1	1.0	3
Nickel chromate	F	Red oak	S	.25[q]	99	2	2.0	97	98.0	----------				3
Zinc chloride	E	Engl. spruce	H	1.07[e]	75	52	69.3	6	8.0	15	20.0	2	2.7	3
Zinc chloride—	T	Engl. spruce	H	.61[e]	83	75	90.4	1	1.2	4	4.8	3	3.6	5
C. t. creosote, grade 1[h]				8.36[r]										

CONDITION OF THE EXPERIMENTAL TIES IN THE UNIVERSITY AVENUE TEST TRACK OF THE CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC RAILROAD AT MADISON, WIS., AT AN INSPECTION IN SEPTEMBER, 1941—Continued

Preservative	Treating method[a]	Species	Form[b] of ties	Average absorption of preservative lb. per cu. ft.	Ties in test	Serviceable		Removed				Not inspected (under crossings)		Missing or eliminated
								Mainly for decay		Causes other than decay[c] and unknown causes				
					No.	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Ties set 1927 to 1929—12 to 14 years service														
Untreated		Corkbark fir	H-S	--------	150	26	17.3	91	60.7	28	18.7	5	3.3	--------
Ties set 1940—1 years service														
Untreated		Blackjack oak	S	--------	24	24	100.0	--------	--------	--------	--------	--------	--------	--------
C. t. creosote, grade 1[b]	F, E	Blackjack oak	S	4.45[s]	69	69	100.0	--------	--------	--------	--------	--------	--------	--------
Zinc chloride	F	Blackjack oak	S	.32[e]	37	37	100.0	--------	--------	--------	--------	--------	--------	1

Note: This test is being conducted in cooperation with the U. S. Forest Products Laboratory. For a detailed description of this test see "University Avenue Test Track at Madison, Wis.", page 136, Proceedings of the American Wood Preservers' Association for 1935.

[a] F = full cell method.
E = empty cell method.
T = two movement method.
[b] H = hewed ties; S = sawed ties; H-S = both hewed and sawed ties.
[c] Rail and plate cutting, splitting, crushing, etc.
[d] 6% solution made by adding 6 gal. of concentrated Aczol solution furnished by Zinsser and Co. to each 94 gal. of water.
[e] Dry salt.
[f] Includes 2 white oak ties.
[g] Includes 4 white oak ties.
[h] A. W. P. A. specifications.
[i] Petroleum.
[j] $Na_2B_4O_7.10H_2O$.
[k] Based on available As_2O_3 in solution.
[m] $Na_2Cr_2O_7.2H_2O$.
[n] Average life 5.9 years.
[o] Based on available $ZnAs_2O_4$ in solution.
[p] Estimated absorption of brine.
[q] Based on sum of nickel sulphate and sodium chromate in solution. The available nickel chromate constitutes 55.1% of the total weight of the two salts.
[r] Creosote.
[s] Based on 45 ties.

Chicago & North Western—Estimated Average Years of Tie Life Obtained From Ties Placed in Test Sections September–December 1914; Also, the Number of Ties Removed up to December 31, 1940

Estimated Average Years Life

Creosote Treatment—7 lb. of creosote per cu. ft. of wood

Location	Yellow birch	Red oak	Hard maple	Loblolly pine	Long leaf pine	Tamarack	Hemlock
40th St. Chicago	27	21	12.2	14.5	15.2	13.3	11.5
Womac, Ill.	33	26	27	23	20.5	17.8	17
Calamus, Iowa	33	24	20	22	19.5	18.1	15.1
Carroll, Iowa	28	33	27	27	21.3	28	19.4
Bark River	33	30	30	33	27	19.1	17
Verdi, Minn.	33	33	30	33	30	30	21
Norfolk, Neb.	33	27	33	33	33	30	24
Chadron, Neb.	33	33	33	33	33	27	28
Av. yrs. life	31.9	28.1	26.5	27.3	24.9	22.9	19.1
Ties placed (1914)	806	800	803	794	800	803	800
Ties removed	81	320	352	381	470	570	694
Ties remaining as of 12-31-40	725	480	451	413	330	233	106

Burnett Treatment—0.50 lb. zinc per cu. ft. of wood

40th st. Chicago	11.4	11.2	13.1	10.0	10.4	11.9	10.4
Womac, Ill.	15.5	14.6	14.8	12.9	16.5	13.2	12.8
Calamus, Iowa	17.6	13.9	16.8	12.3	13.5	15.9	14.3
Carroll, Iowa	19.1	16.3	18.8	13.8	19.0	19.8	17.1
Bark River	14.7	22.5	19.7	17.5	19.0	17.5	16.8
Verdi, Minn.	21.5	30.0	23.0	17.0	16.6	24.0	22.0
Norfolk, Neb.	27	17.0	22.0	15.8	16.2	19.8	18.6
Chadron, Neb.	23	18.0	26	13.8	17.8	21.4	20.0
Av. yrs. life	18.7	17.9	19.3	14.1	16.1	17.9	16.5
Ties placed (1914)	803	783	803	794	802	800	798
Ties removed	729	691	712	773	774	724	774
Ties remaining as of 12-31-40	74	92	91	21	28	76	24

Chicago & North Western—Estimated Average Years of Tie Life Obtained From Ties Placed in Test Sections September–December 1914; Also, the Number of Ties Removed up to December, 31, 1940—Continued

Card Treatment—0.43 lb. zinc—1.8 lb. creosote per cu. ft. of wood

Location	Yellow birch	Red oak	Hard maple	Loblolly pine	Long leaf pine	Tamarack	Hemlock
40th st. Chicago	13.5	12.2	13.4	11.1	11.0	11.4	11.0
Womac, Ill.	14.5	17.1	14.3	17.3	15.8	14.0	13.7
Calamus, Iowa	14.8	13.6	16.1	15.9	16.0	15.1	14.9
Carroll, Iowa	17.4	18.5	18.7	17.4	19.0	24.0	19.5
Bark River	14.0	23.0	19.7	20.0	21.0	17.7	16.0
Verdi, Minn.	19.0	25.0	20.4	17.6	21.0	23.0	22.0
Norfolk, Neb.	18.0	18.5	20.6	16.3	15.4	16.2	18.0
Chadron, Neb.	22.0	23.0	26.0	21.9	18.0	22.4	21.0
Av. yrs. life	16.7	18.9	18.7	17.2	17.1	18.0	17.0
Ties placed (1914)	793	799	799	806	793	802	801
Ties removed	769	700	745	759	729	722	755
Ties remaining as of 12-31-40	24	99	54	47	64	80	46
Untreated							
40th st. Chicago	5.00	6.14	8.49	4.96	5.64	7.06	5.34
Womac, Ill.	4.76	6.61	4.69	5.27	5.69	6.59	6.79
Calamus, Iowa	5.00	7.90	5.00	6.00	6.00	9.78	7.00
Carroll, Iowa	5.63	6.54	5.96	6.26	4.04	7.15	7.23
Bark River	5.17	8.04	5.45	7.07	9.46	8.09	7.98
Verdi, Minn.	4.79	5.80	5.96	3.00	5.11	6.51	7.67
Norfolk, Neb.	4.99	5.76	5.47	3.53	4.81	5.43	4.61
Chadron, Neb.	6.16	5.52	6.12	4.26	6.14	6.00	7.06
Av. yrs. life	5.20	6.54	5.89	5.04	5.87	7.08	6.71
Ties placed (1914) (All ties removed.)	800	799	800	799	792	801	798

Chicago & North Western—Estimated Average Years of Tie Life Obtained From Ties Placed in Test Sections September–December 1914; Also, the Number of Ties Removed up to December, 31, 1940—Continued

	T. G. S. oil[x]
40th st. Chicago	20
Womac, Ill.	27
Calamus, Iowa	21
Carroll, Iowa	28
Bark River	33
Verdi, Minn.	33
Norfolk, Neb.	33
Chadron, Neb.	33
Av. yrs. life (Loblolly pine)	28.5
Ties placed (1914)	799
Ties removed	306
Ties remaining as of 12-31-40	493

Summary—as of December 31, 1940

Treatment	Total number of ties: Placed	Removed	Remaining	Per cent
Creosote	5,606	3,512	2,094	37.4
Burnett	5,583	5,177	406	7.3
Card	5,593	5,179	414	7.4
Untreated	5,589	5,589		
T. G. S. Oil	799	306	493	61.6
	23,170	19,763	3,407	

x Consists of 50 percent water-gas tar and 50 percent coke-oven tar.

Summary—Estimated Average Years Life

Poor: Untreated	Yrs.	Good: Burnett	Yrs.	Better: Creosote	Yrs.	Percent removed	Best: Creosote	Yrs.	Percent removed
Loblolly pine	5.04	Loblolly pine	14.1	Tamarack	22.9	71	Hard maple	26.5	44
Yellow birch	5.20	Long leaf pine	16.1	Long leaf pine	24.9	59	Loblolly pine	27.3	48
Long leaf pine	5.87	Hemlock	16.5				Red oak	28.1	40
Hard maple	5.89	Red oak	17.9				T.G.S. (tar)		
Red oak	6.54	Tamarack	17.9				Loblolly pine	28.5	38.4
Hemlock	6.71	Yellow birch	18.7				Creosote		
Tamarack	7.08	Creosote					Yellow birch	31.9	10
		Hemlock	19.1						

Note:—Estimate as of 12-31-40. This is 26 years after the installation. 800 ties in each group. (Office of chief engineer C&NW, Chicago, Sept. 3, 1941.)

Northern Pacific—Hemlock Test Track

(Designated by U. S. Forest Service as Project L–214)

1800 Montana–Idaho hewed and sawed ties placed between Mile Post 120 and Mile Post 121—2350, westward main track, Missoula, Mont.

Treated at Paradise, Mont. with 80–20 creosote-coal tar solution, 6¾ lb. per cu. ft., Lowry process, and placed in track in 1910.

Summary of Ties by Species

Year	Western hemlock	Western larch	Douglas fir	True fir	Spruce	White pine	Ponderosa pine	Aspen	Total
1910	1072	436	166	102	18	2	3	1	1800
Year					Renewals				
1917	1	----	----	----	----	----	----	----	1
1924	1	----	----	----	----	----	----	----	1
1926	4	----	----	----	----	----	----	----	4
1928	43	----	----	----	----	----	----	----	43
1929	26	8	6	14	5	----	----	----	59
1932	49	9	----	----	3	----	----	----	61
1933	28	8	4	1	1	----	----	----	42
1934	43	18	1	6	----	----	----	----	68
1935	29	9	5	4	----	----	----	----	47
1936	42	11	3	1	----	----	1	----	58
1937	78	24	4	5	4	----	----	----	115
1938	72	24	1	6	----	----	----	----	103
1939	43	16	3	4	1	----	----	----	67
1940	80	22	5	8	----	1	----	----	116
1941	54	23	5	1	----	----	----	----	83
Total	593	172	37	50	14	1	1	0	868
Per cent renewed	55.31	37.84	22.28	49.01	77.78	50.00	33.33	0	48.22
Avg. yrs. per tie	26.04	26.82	25.97	24.98	22.93	30.00	26.00	0	26.02

Six ties removed prior to 1928 were broken by derailment. Others all removed account decay hastened by damage from past derailments and mechanical action at rail base.

48.22 per cent renewals in 31 years.

Average life of ties replaced—26.02 years.

Estimated total life based on Tie-Life Curve of the United States Forest Products Laboratory—33.3 years.

Northern Pacific—Tamarack Test Track

44,159 Hewed Minnesota tamarack ties placed between Mile Post 88 and 103½, in eastward main track, Rice, Minn., to Gregory.

Treated at Brainerd, Minn., with 80–20 creosote-coal tar solution, 6¾ lb. per cu. ft. Lowry process and placed in track in 1917.

Renewals

None previous to 1928.

1928—	1	tie account decay. Showed signs of having been partially decayed when treated.
1929—	239	ties account derailment.
1930—		No renewals.
1931—	3	ties account decay.
1932—		No renewals.
1933—		No renewals.
1934—		No renewals.
1935—	214	decay at rail base caused by mechanical action.
1936—	1785	decay at rail base caused by mechanical action.
1937—	3002	decay at rail base caused by mechanical action.
1938—	3454	decay at rail base caused by mechanical action.
1939—	2448	decay at rail base caused by mechanical action.
1940—	8872	decay at rail base caused by mechanical action.
1941—	6996	decay at rail base caused by mechanical action.
	27014	ties renewed, 61.17 per cent, after 24 years.

Average life of ties renewed—22.18 years.

Estimated total life based on tie life curve of the United States Forest Products Laboratory—24 years.

Report on Northern Pacific Test Tracks at Plains, Thompson Falls, Missoula, and Lolo, Montana

By C. N. WHITNEY
Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Mont.

Thirty-five years ago the Forest Service entered into a cooperative study of crossties with the Northern Pacific Railway. The series of experiments undertaken at that time led to the installation of a test track at Plains, Mont., in 1907. In later years, representatives of the Forest Service have taken part in the collection of service records of experimental ties in three other Northern Pacific test tracks established more than a quarter of a century ago. This report, under separate headings, presents the results of these four studies of the durability of treated and untreated native woods when used in the form of crossties.

Test Track at Plains

The ties for this test were placed in the railroad's main line near Plains, Mont., early in 1907. The test included 2,260 untreated ties of western larch and Douglas fir plus 390 zinc chloride treated ties of the same species. Treatment of the ties was done by a pressure process using a 6-percent solution of zinc chloride; absorption of the preservative amounted to 0.8 lb. per cu. ft.

The principal purpose of this test was to determine the durability of green, seasoned, and treated ties cut at different seasons of the year. However, it was also desired to compare the effect of three forms of tie plates in reducing mechanical abrasion and to test the value of screw spikes as compared with ordinary cut spikes.

The seasoning experiment was carried on at Sandpoint, Idaho, using Douglas fir and western larch ties produced in Idaho and cut in different months. The results of that phase of the investigation, together with a complete description of the laying of the test track at Plains, have been previously published.*

The ties were hewed, and varied much in size and shape. They were all laid on a tangent in a continuous stretch. There was a uniform grade of 0.0167 percent over the entire test track. All of the treated and most of the untreated ties were set in a filled roadbed which was well drained.

Results of this experiment, given in Table 1, show that the average life for the untreated larch was 7.35 years and for the untreated Douglas fir, 7.65 years. The treated Douglas fir ties gave an average life of 17.5 years and the treated western larch, an average life of 18.6 years.

Test Track at Thompson Falls

In order to carry on this study a test track was established in the main line of the railroad during October 1915, with the Forest Service and the Northern Pacific Railway cooperating. The purpose was to determine the comparative durability of creosoted Douglas fir, white fir, ponderosa pine, and western larch ties. In addition, it was desired to compare the value of Vignoles rail chairs with standard Northern Pacific plates in reducing mechanical wear and splitting.

This test track originally included 1,675 ties, of which 1,575 were creosoted and 100 were set untreated. It contains 489 ft. of tangent between a reverse curve of 1 deg. and

* "Experiments with Railway Cross-Ties," by H. B. Eastman, forest assistant. U.S.D.A. Forest Service Circular 146. Issued April 25, 1908.

TABLE 1.—SUMMARY OF RESULTS FOR THE NORTHERN PACIFIC TEST TRACK NEAR PLAINS, MONTANA

Ties set in spring of 1907

Description of ties and preservative treatment	Date of final inspection	Number in test	Total renewals because of wear, breakage, splitting, and decay	Average life
			Per cent	Years
Douglas fir. Pressure-treated with zinc chloride, 0.8 lb. per cu. ft.	June 1932	197	100.0	17.5
Douglas fir. Green, untreated	June 1916	570	100.0	7.6
Douglas fir. Seasoned, untreated	June 1916	571	100.0	7.7
Western larch. Pressure-treated with zinc chloride, 0.8 lb. per cu. ft.	June 1932	193	100.0	18.6
Western larch. Green, untreated	June 1916	551	100.0	7.3
Western larch. Seasoned, untreated	June 1916	568	100.0	7.4
Summary				
Treated ties, both species		390	100.0	18.0
Untreated ties, both species		2,260	100.0	7.5

2 deg., and it is considered to be fairly representative of the results obtainable from the various species under mainline conditions.

About half of the test ties were equipped with Vignoles bolted rail fastenings, which provided for all lateral and vertical adjustments of the rail to the tie without removing bolts. The remainder of the ties were originally equipped with 7-in. by 9-in. Northern Pacific tie plates. The track was originally laid with 90-lb. rails, but in 1925 the entire test track was relaid with 100-lb. rails. When this work was done all of the old Northern Pacific tie plates and the Vignoles rail chairs were replaced with the new Northern Pacific tie plates of the latest type. The principal reason for removing all of the rail chairs was that the nuts holding the plates could not be properly tightened because of wornout threads. As long as it was possible to use them, the Vignoles rail chairs rendered good service in preventing excessive plate wear and splitting of the ties.

Table 2 gives data on the durability of the treated ties placed in the track. Although many are still in service, it is estimated that the average life of all treated ties will be close to 24.5 years.

All untreated ties, consisting of 50 Rocky Mountain Douglas fir and 50 western larch ties, were replaced during the period from 1921 to 1926 because of decay. The untreated Douglas fir ties gave an average life of 7.5 years and the untreated larch, an average life of 6.9 years.

HEMLOCK TEST TRACK AT MISSOULA

Early in 1910, the Northern Pacific established a test track near Missoula, Mont., to determine the serviceability of treated western hemlock crossties. When the hemlock ties were laid, some ties of other species were placed in the same test section. However, prior to 1928 the number of ties other than hemlock had not been definitely reported. Therefore, in 1928 officers of the Forest Service and the railroad cooperated in determining the exact number of each species. This recheck included an examination of 1,800 ties, of which 1,368 were identified in the field. Small samples of all doubtful ties were sent to the Forest Products Laboratory for positive identification. When all of the identification work had been completed it was found that the installation originally contained 1,072 Inland Empire hemlock ties, 436 western larch, 166 Rocky Mountain Douglas fir, 102 true fir, 18 Engelmann spruce, and 6 ties of other species. The entire

TABLE 2.—SUMMARY OF 1941 INSPECTION OF TREATED TIES IN NORTHERN PACIFIC TEST TRACK NEAR THOMPSON FALLS, MONTANA

Results of 26 Years' Service

Ties set in October 1915

Species	Form	Preservative	Process	Absorption per cu. ft. lb.	Track group numbers[1]	Curvature of track deg.	Total ties set number	Eliminated on account of plate trouble[2] number	Ties in test number	Total renewals (on account of wear, splitting, breakage, and decay)[3] Number	Per cent	Estimated average life[4] years
Douglas fir (Rocky Mt. type)	123 hewed 27 sawed	Creosote	Bethell[5]	6.2	1, 9, 10	2	150	12	138	106	76.8	23.4
Douglas fir (Rocky Mt. type)	215 hewed 30 sawed	Creosote	Bethell[5]	6.2	22, 25, 27	1	245	2	243	178	73.3	24.3
Western larch	108 hewed 43 sawed	Creosote	Bethell[5]	9.0	2, 8, 11	2	151	3	148	114	77.0	23.2
Western larch	141 hewed 80 sawed	Creosote	Bethell[5]	9.0	21, 24, 26	1	221	1	220	175	79.5	23.0
Lodgepole pine	100 hewed	Creosote	Lowry	8.6	3, 12	2	100	3	97	88	90.7	21.0
Lodgepole pine	99 hewed	Creosote	Lowry	8.6	16, 17	0	99	6	93	82	88.2	21.3
White fir (*Abies grandis*)	101 hewed	Creosote	Lowry	9.1	5, 14	2	101	3	98	89	90.8	21.0
White fir (*Abies grandis*)	99 hewed	Creosote	Lowry	9.1	15, 18	0	99	1	98	70	71.4	24.5
Ponderosa pine[6]	4 hewed 98 sawed	Creosote	Lowry	7.3	4, 13	2	102	11	91	38	41.8	29.2
Ponderosa pine[6]	8 hewed 215 sawed	Creosote	Lowry	7.3	20, 23	1	223	30	193	94	48.7	28.3
Ponderosa pine[6]	2 hewed 82 sawed	Creosote	Lowry	7.3	19	0	84	0	84	28	33.3	31.7
Total	802 hewed 773 sawed	------	------	------	--------	------	1,575	72	1,503	1,062	70.7	------

[1] For the past 16 years all ties have been equipped with 7¾ in. by 10⅞ in. Northern Pacific standard tie plates. The two types of Vignoles plates and the original Northern Pacific plates placed in 1915, to study wear from different types of rail fastenings, were replaced in 1925. Therefore the service records of all groups covering the same species have now been summarized by track curvature rather than by type of plate.

[2] Includes 6 sound ties equipped with type SS Vignoles plates, removed from track in April 1923 for inspection, and 66 sound ties similarly equipped removed in April 1925 because it proved practically impossible to detach the plates from these ties without taking them out of the track.

[3] Records from annual inspections prior to 1938 indicate that during the first 22 years of service, 169 ties or approximately 28 per cent of all test ties replaced were removed from the track because of plate wear and splitting, and 442 ties, or about 72 per cent, were removed because of decay which had been accelerated by wear and splitting at the rail base. Inspections made from 1938 to 1941, inclusive, have shown that all ties removed were so badly decayed, split, or crushed under the rail seats that they were no longer capable of holding spikes. About 15 ties or 1½ per cent of all test ties replaced were removed because of breakage due to cross grain or large knots. A few of the ties broken had become centerbound in the track.

[4] Computed from percentages of renewals and corresponding average life expectancies indicated by Tie Life Curve of Forest Products Laboratory.

[5] Preliminary steaming.

[6] Prior to 1932 reported under the name "western yellow pine."

TABLE 3.—CONDITION OF RAILWAY TIES IN THE NORTHERN PACIFIC TEST TRACK AT MISSOULA, MONTANA

Ties set in March 1910

Description of ties and preservative treatment	Average age at time inspected, June 1941 years	Number in test	Total renewals because of wear, breakage, splitting, and decay Number	Total renewals because of wear, breakage, splitting, and decay Per cent	Estimated average life years
Western hemlock. Pressure-treated with creosote-coal tar solution (80 per cent Grade 1 creosote and 20 per cent refined coal tar) 6¾ lb. per cu. ft.	31.2	1,072	594	55.4	33.0
Western larch. Same treatment and preservative	31.2	436	172	39.5	35.0
Douglas fir. Same treatment and preservative	31.2	166	37	22.3	38.0
True fir (probably grand fir). Same treatment and preservative	31.2	102	50	49.0	32.0
Engelmann spruce. Same treatment and preservative	31.2	18	14	77.8	28.0
Idaho white pine. Same treatment and preservative	31.2	2	2	100.0	30.5[1]
Ponderosa pine. Same treatment and preservative	31.2	3	1	33.3	36.0
Aspen. Same treatment and preservative	31.2	1	-----	-----	----
Summary					
Treated ties, all species	31.2	1,800	870	48.3	33.8

[1] Actual average life (end of test).

test is located in main line track between Mile Post 120 and Mile Post 121 + 2350, at the west end of the Missoula yard.

All ties in the test track were treated by the Lowry pressure process with 6¾ lb. per cu. ft. of a creosote-coal tar solution, consisting of 80 percent Grade 1 creosote and 20 percent refined coal tar. The ties were originally laid without tie plates, but after about 2 years were equipped with 7-in. by 9-in. tie plates. In 1926 the track was relaid with 100-lb. rail and 7¾-in. by 10¾-in. Northern Pacific standard plates. The ballast is ordinary pit-run gravel and drainage is not considered good.

Since 1928, representatives of the Forest Service have helped to make annual inspections of these ties. At the 1941 inspection, after 31 years of service, renewals of the western hemlock ties amounted to 55.4 percent, and indications are that the average life will be close to 33 years.

Comparative service records for the experimental ties of each species in this test track are given in Table 3.

COTTONWOOD TEST TRACK AT LOLO

Soon after the completion of the Northern Pacific tie-treating plant at Paradise, Mont., in April 1908, the railroad installed several test tracks. One of these test tracks was established in March, 1910, near Lolo, Mont., in the Bitterroot branch line. This test section includes 261 creosoted cottonwood ties cut in western Montana.

The ties were air seasoned, not bored nor incised, and were treated by the Lowry process. They were impregnated with a solution of 80 percent Grade 1 creosote and 20 percent refined coal tar. Net absorption of the preservative amounted to approximately 8 lb. per cu. ft. of wood. The ties were originally laid with dirt ballast and 56-lb. rail. In 1918 the ties were equipped with 6½-in. by 8-in. plates, and in 1923 the track was

TABLE 4.—CONDITION OF RAILWAY TIES IN THE NORTHERN PACIFIC TEST TRACK (BITTERROOT BRANCH LINE) NEAR LOLO, MONTANA

Ties set in March 1910

Description of ties and preservative treatment	Average age at time inspected, June 1941	Number in test	Condition of ties, June 1941				Estimated average life
			Good[1] per cent	Fair[2] per cent	Poor[3] per cent	Removed because of wear, splitting, breakage and decay per cent	
	years						years
Cottonwood. Pressure-treated with creosote-coal tar solution, 80 per cent Grade 1 creosote and 20 per cent refined coal tar, 8 lb. per cu. ft.	31.3	261	11.9	39.8	28.8	19.5	38

[1] "Good" condition means life expectancy of 5 years or more.
[2] "Fair" condition means life expectancy of 3 to 4 years.
[3] "Poor" condition means life expectancy of 1 to 2 years.

relaid with 85-lb. rail. Traffic on this branch is not heavy, but during the period when the ties were not protected by tie plates there was some damage from mechanical wear.

For the past eight years a representative of the Forest Service has accompanied officers of the railroad on their annual inspections of these experimental ties. At the 1941 inspection, after 31 years of service, 210 or 80.5 percent of the original ties were still in place. Of this number, 31 were classed as being in good condition and capable of giving at least 5 additional years of service, 104 were classified as being in fair condition with an additional life expectancy of 3 to 4 years, and 75 were classed as badly decayed and needing renewal within about 2 years. With only 51 new ties laid, or 19.5 percent renewals in 31 years, less than 80 percent of the average life of the original ties laid has been realized, and it is expected that the average life to be shown by final figures will be close to 38 years.

The results obtained in this study clearly show the wisdom and economy of treating ties of the so-called minor species, such as cottonwood. The detailed service records for this installation are contained in Table 4.

Conclusions

Records obtained from the Plains test track show that there was practically no difference in the relative durability of untreated green and seasoned ties of either Douglas fir or western larch. Irrespective of track equipment, the average life for the green and seasoned larch proved to be 7.3 years and 7.4 years, respectively. The average life for the green and seasoned Douglas fir ties was 7.6 years and 7.7 years, respectively.

The service life figures of 17.5 years for Douglas fir and 18.6 years for western larch, as obtained from zinc chloride treated ties in the Plains test track, are considered to be above the averages generally obtainable from this type of preservative. After some years of service all of the treated ties in this test were turned over, and this undoubtedly increased their life. Also tending to prolong the life of these test ties was the use of a 6-percent solution of zinc chloride resulting in a net retention of 0.8 lb. of dry salt per cubic foot, rather than the 4-percent solution with ½-lb. net retention specified in many instances for zinc chloride treatments.

The most severe test of the lasting qualities of the various species included in the Thompson Falls test track was that given to each of the groups on the two-degree curve. At the latest inspection of the creosoted ties in this test, after 26 years of service, the life expectancies of the Douglas fir and western larch ties on that curve appeared to be about equal. On the same curve, the treated lodgepole pine and white fir ties also showed very little difference in their comparative life expectancies. The treated ponderosa pine ties will have a considerably longer life than any of the other species included in this study, both on the tangent and on the curves.

Although the Northern Pacific test track at Missoula is on the main line, it is not a high speed track and does not contain steep grades or sharp curves. Consequently, the average life figures resulting from this test will be somewhat higher than can be obtained throughout the Rocky Mountain division.

Report on Assignment 3

Destruction by Marine Organisms and Possible Ways of Prevention

W. F. Clapp (chairman, subcommittee), W. P. Arnold, S. J. Buckman, C. M. Burpee, E. A. Craft, John Foley, A. M. Knowles, F. B. Robins, Hermann von Schrenk.

The following report includes the results of the inspection of the various test timbers and other data on the subject assigned, which are offered as information with the recommendation that the subject be continued.

Turpentine Wood

No report has been received regarding the condition of the 32 turpentine piles of the Southern Pacific Company in the pier at Oakland, Calif.

Panama Canal

Through Col. William G. Atwood, the report by Mr. James Zetek has been received from Gen. Glenn B. Edgerton, governor of the Canal Zone. The inspections were made on August 4, 1941, and the report is presented below:

> In general there was less marine growth on the timbers, and very few had any appreciable amount of silt. But the most curious finding was that all of the pholads *(Hiata infelix* and *Martesia striata)* were dead. No explanation can be given for this mortality. The gribble *limnoria lignorum,* was much more plentiful than in previous years, and some of the timbers show much more gribble damage.
>
> The new teredo, Bankia (Nausitoria) Jamesi Bartsch, found last year in red mangrove, was practically non-existent, and in the red mangrove we had instead *neobankia zeteki* Bartsch, which is our dominantly destructive teredo.
>
> Neither Sphaeroma nor Chelura was found, and nothing resembling their work was seen.
>
> Red mangrove is definitely a failure. The teredo works in it freely and rapidly.
>
> Mata–Sarno from the Galapagos is showing active teredo invasion.
>
> Guayacan from Panama had a few teredos, but it has not been long enough in the test. I doubt if it is very resistant to the teredo.
>
> A—Untreated Timbers
>
> 1609–2 Anoura, *Conepia sp.,* Dutch Guiana, submerged September 13, 1923 (Rack 26). Fair amount of marine growth on all surfaces. Gribble damage was about the same as last year, one face deeper than the other three. No live pholads present. Teredos were confined close to surfaces; most of them were small; a few were $\frac{3}{16}$ in. in diameter. Teredos were live. Actual teredo damage is very light; most of the destruction is due to the pholads; and except for this damage, the timber is sound.
>
> 1612–3 Basra Locus (Angelizue), *Dicorynia paraensis* Bentham. Dutch Guiana (Rack 29), submerged September 13, 1923. Fair amount of marine growth on all surfaces. Gribble work not serious, rather light, about as last year. No live pholads seen. Teredos were live, all small, more plentiful than in Anoura, confined close to the surfaces. The timber is very sound.
>
> 1608–4 Foengo, *Parinarium campestre* Aubl. Dutch Guiana (Rack 32) submerged September 13, 1923. Marine growth was very abundant on all surfaces. Gribble work was about as in Anoura, one face badly attacked, and these crustaceans were rather plentiful and at work. The teredo was no worse than last year, small individuals confined close to the surfaces. No live pholads were seen. The timber, except for the surface deterioration, is very sound.

1610–5 Sponse Hoedoe, *Licania macrophylla* Bentham. Dutch Guiana (Rack 33) submerged September 13, 1923. Marine growth plentiful on all surfaces. Pholad damage is very bad on two faces but no live pholads were seen. Gribble damage is about as in Basra Locus, about ½ in. on one face. Teredo as last year, all small and close to surfaces, not plentiful. The timber otherwise is very sound.

1613–7 Manbarklak, *Eschwilera longipes* Miers. Dutch Guiana (Rack 34) submerged September 13, 1923. Abundant marine growth. No live pholads. Gribble at work, but slow progress except on one face. Teredo as before, small, few in number and close to surfaces. Except as noted, the timber is very sound.

1606–9 Malabayabas, *Tristania decorticata* Merr. Philippine Islands (Rack 35) submerged September 13, 1923. Considerable silt and marine growth. No live pholads but one face shows deep damage from both species. Gribble damage light, more on one face. The teredos are very small, few in number and confined close to the surfaces. Except for the pholad work, this timber is very sound.

1615–11 Kajol Lara, *Metrosideros sp.*, Celebes, (Rack 36) submerged October 26, 1925. Considerable marine growth. No live pholads. Gribble work very light, teredos few in number, small, close to surfaces. This timber is in very good shape.

1612–12 Kajol Malas, *Parastemon urophyllum,* Sumatra (Rack 23) submerged October 26, 1925. Considerable marine growth. No live pholads. Gribble work light but more than in Kajol Lara. Teredo unimportant, small, few in number, confined close to surfaces. Timber very sound.

1637–13 Kolaka, Celebes (Rack 13) submerged April 15, 1932. Relatively free of marine growth. Gribbles active, more destruction since last year, yet not deep. No live pholads. Teredos are unimportant, few in number, small, close to surfaces. The timber is very sound.

1617–14 Alcornoque, *Dimorphandra mora,* B. & H. Panama, all heartwood, (Rack 14) submerged November 22, 1927. Abundant marine growth. No live pholads. Gribble work very light. Teredos as before limited in number, close to the surfaces, small. This timber is in very good shape.

1625–22 Brush Box. New South Wales (Rack 22) submerged September 19, 1929. Much silt. Abundant marine growth. No live pholads. Gribble work practically nil except one face (not bad), however teredos appear to be more plentiful but are all small and close to surfaces. The timber is very sound.

1621–27 Turpentine Wood, *Syncarpia laurifolia.* New South Wales, (Rack 27) submerged April 19, 1929. Abundant marine growth. No live pholads. Gribble work is very light, slightly more on one face. Teredos small, few in number, close to surfaces. The timber is very sound.

1621–25 Turpentine Wood, *Syncarpia laurifolia.* New South Wales, (Rack 25) submerged April 19, 1929. Marine growth abundant. No live pholads. Gribble work not pronounced.

Since we have two samples of this wood and this one was in worse shape than the other one, and showed increased teredo activity, it was removed from the test. Upon dissection we found many more teredo than a surface examination indicated, some of these ⅜ in. in diameter, all live and some very large. The center of the timber was quite free of teredo. The surfaces showed much pholad damage, one face was especially bad. *Closed.*

1645–16 Red Mangrove *Rhizophora mangle L.* Colombia (Pacific Side) (Rack 16) submerged April 19, 1940. Hence only about 15-months exposure. Marine growth nil. Much silt. No pholads. Teredo *very* abundant, live, active.

We removed this wood from the test. Last year we found a new teredo present, Bankia (Nausitoria) jamesi Bartsch, the second largest teredo known. Upon dissection we found very few of this species, but an unbelievable number of Neobankia zeteki Bartsch. In fact it was so thoroughly full of large live teredos that no matter where we slit the wood we ran into teredos.

Since we now know that red mangrove does not inhibit teredos, nor is it immune to termites, we can discard it from further consideration. This does not mean that it may have good use elsewhere. I see no need of photographing the teredo picture since a description suffices. *Closed.*

1646–17 Red Mangrove, *Rhizophora mangle L.* Colombia (Pacific Side) (Rack 17) submerged April 19, 1940. Marine growth nil; no pholads seen; gribble nil, but teredos very very plentiful; and the timber is in bad shape and could have been removed. It will be removed next year. A failure.

1647–10 Red Mangrove, same lot as preceding ones. Submerged November 15, 1940, (Rack 10) hence 8-months exposure. Some marine growth, considerable silt, no pholads noted. Teredos are active, very abundant.

1648–11 Red Mangrove, same lot as preceding ones. Submerged November 15, 1940, (Rack 11) considerable marine growth, much silt, no pholads, no gribble, but teredos are very plentiful, and very active.

1650–10 Guayacan, *Tabebuia guayacan.* Panama, 10 in. × 5 in. × 48 in. (Rack 19) submerged November 27, 1940. Considerable marine growth, some silt. No pholads and no gribble. No evidence of teredo.

1651–20 Guayacan, *Tabebuia guayacan.* Panama, 10 in. × 5 in. × 48 in. (Rack 20) submerged November 27, 1940. Fair amount of marine growth, no gribble, no pholads, two small live teredos found at one edge.

1649–30 Mata-Sarno. Galapagos, 6 in. × 6 in. × 19 in. (Rack 28) submerged November 23, 1940. Considerable marine growth. Gribble nil. No pholads seen. One face has a large soft area with very many live teredos working in it, ⅛ in. to $\frac{3}{16}$ in. in diameter. There are some teredos along the sides, all small.

Chemical Warfare Service Specimens

No report has been received on the condition of the treated pieces which were prepared by the Chemical Warfare Service in 1931. A large proportion of these treated timbers have been reported in previous years in the Proceedings of the AREA as having been discarded after varying periods of exposure.

San Francisco Bay Tests

From Mr. W. H. Kirkbride the following report of the results of inspection on August 28, 1941, of test pieces exposed to marine borers at Oakland Pier, Calif., and Peralta Street wharf, West Oakland, has been received.*

The untreated test pieces at Oakland Pier show heavy limnoria attack and very few teredos. At Peralta Street, the attack by all borers was moderate. Losses in weight were as follows:

Oakland Pier	20 percent	For the year.
Peralta Street wharf	7 percent	

Shell Development Company test pieces show attack as follows:

Oakland Pier

A–1 and A–2. Moderate limnoria attack in both; 1 teredo in A–1.
B–1 and B–2. Very light limnoria attack on sides; moderate attack on ends.
C–1 and C–2. Light limnoria attack on one side of each piece.
D–1 and D–2. Lost last year, recovered this year. Moderate limnoria attack.

Peralta Street Wharf

A–3 and A–4. Moderate limnoria attack, a few teredos in A–3.
B–3 and B–4. Moderate limnoria attack.
C–3 and C–4. Light limnoria attack.
D–3 and D–4. Moderate limnoria attack.

Report of Inspection August 28, 1941, of Specimens Furnished Through Dr. Hermann von Schrenk and Col. W. G. Atwood and Installed in San Francisco Bay Area

Barrett Manufacturing Company Material

Placed at Station B, Pier 7, San Francisco, January 1923. Moved to Biological Station, Oakland Pier, care S. P. Co., December 1925.

* Data on test piles at Long Beach, Calif., and San Pedro, received too late for publication, will appear in the next report.

Gate	Specimen Number	Treatment	Condition Aug. 28, 1941
B– 4	P– 1	Coke oven original oil	Very light limnoria attack
	P– 2	do solids removed	No fresh attack
	P– 3	do acids removed	do
	P– 4	do bases removed	Very light limnoria attack
B– 5	P– 5	Coke, minus residue at 360° C.	Very light limnoria attack
	P– 6	do fraction 230°–270° C.	No fresh attack
	P– 7	do fraction up to 230° C.	do
	P– 8	do fraction 270°–360° C.	Very light limnoria attack
B– 6	P– 9	Vertical retort original oil	Very light limnoria attack
	P–10	do minus solids	do
	P–11	do minus acids	do
	P–12	do minus bases	do
B– 7	P–13	do minus residue above 360° C.	Light limnoria attack
	P–14	do minus fraction 230°–270° C.	do
	P–15	do minus fraction up to 230° C.	do
	P–16	do minus fraction 270°–360° C.	do
	F– 2	do P– 2	Light limnoria attack
B– 8	F– 1	Same as P– 1	Very light limnoria attack
	F– 3	do P– 3	do
	F– 4	do P– 4	do
B– 9	F– 5	do P– 5	Very light limnoria attack
	F– 6	do P– 6	No fresh attack
	F– 7	do P– 7	do
	F– 8	do P– 8	Very light limnoria attack
B–10	F– 9	do P– 9	Light limnoria attack
	F–10	do P–10	Very light limnoria attack
	F–11	do P–11	do
	F–12	do P–12	do
B–11	F–13	do P–13	Very light limnoria attack
	F–14	do P–14	do
	F–15	do P–15	do
	F–16	do P–16	do

Note.—P = Pine; F = Fir.

The untreated specimens at this station 1940–41 show heavy limnoria attack and very few teredos.

Report of Inspection on August 28, 1941, of Specimens Furnished by Chemical Warfare Service and Placed in San Francisco Bay at Request of Dr. Hermann von Schrenk

Gate 25–1–A

Installed at Biological Station, Oakland Pier, July 21, 1925. The untreated pieces hung at this station show heavy limnoria attack and a few teredos.

No. 1 (1 percent Ammoniacal Copper Carbonate). Very light limnoria attack. Light limnoria attack on ends in 1934.

No. 2 (Creosote and 1 percent Diphenylamine Chlorarsine). No attack.

Gate 25–1–B

Installed at Ferry Slip, Port Costa, July 22, 1925. Removed to Peralta Street wharf, Oakland, September 1930. Pieces are duplicates of Gate 25–1–A.

No. 2 Moderate limnoria attack on sides only. Previous inspections showed very light limnoria attack on sides in 1934; light spot in 1933.

Untreated pieces hung at this point in 1940 and 1941 showed moderate limnoria, teredo and bankia attack.

Chemical Warfare Service Test Pieces Forwarded From Edgewood Arsenal by Lt. Col. C. E. Brigham, and Hung at Peralta St. Wharf on February 24, 1932

Inspected August 28, 1941

Piece No.	*Treatment and Retention*	*Condition*
A–12	Creosote, 21.6 lb. per cu. ft.	Very light limnoria attack on sides; heavy attack in heartwood of ends.
B–12	Creosote plus 0.71 percent Methyl Arsenious oxide, 21.0 lb. per cu. ft.	Heavy limnoria attack in heartwood of ends; no fresh attack on sides.
C–12	Creosote plus 0.77 percent Diphenylamine chlorarsine, 24.4 lb. per cu. ft.	Moderate limnoria attack on sides; heavy attack in heartwood of ends.
D–12	Creosote plus 2½ percent Dinitrophenol 23.7 lb. per cu. ft.	Very light limnoria attack on sides; heavy limnoria attack in heartwood of one end.
E–12	Petroleum residuum plus 2½ percent dinitrophenol, 22.5 lb. per cu. ft.	Heavy limnoria and bankia attack on sides and ends.
F–12	Petroleum residuum plus 0.84 percent methyl arsenious oxide, 17.5 lb. per cu. ft.	ditto
G–12	Petroleum residuum plus 0.87 percent diphenylamine chlorarsine, 16 lb. per cu. ft.	ditto

Untreated pieces hung at Peralta Street wharf 1940–1941 showed moderate limnoria, teredo and bankia attack.

Chemical Warfare Service Test Pieces Forwarded From Edgewood Arsenal by Lt. Col. C. E. Brigham and Hung at Oakland Pier February 24, 1932

Inspected August 28, 1941

Specimen No.	*Treatment*	*Condition*
A–11	duplicate of A–12	Heavy limnoria attack around a knot and in heartwood on ends; very light elsewhere.
D–11	duplicate of D–12	Very light limnoria attack on sides; moderate attack in heartwood on ends.
E–11	duplicate of E–12	Heavy limnoria attack.
F–11	duplicate of F–12	Heavy limnoria and light teredo attack.

Untreated pieces hung at Oakland Pier 1940–1941 showed heavy limnoria attack and very few teredos.

The present condition of the series of creosoted fir test piles driven at four locations on the Pacific Coast has not been reported.

Progress Report on Results Obtained at the Testing Stations

Arsenious Sulphide.—exposed to marine borer attack. Southern yellow pine logs, 5 ft. in length, 8 in. in diam.

Newport, R. I. submerged May 29, 1936. No borer activity September 2, 1936. Heavy attack April 30, 1938. Test discontinued.

Limon, Costa Rica submerged September 10, 1936—5 logs. Slight teredo attack February 13, 1937. Heavy attack August 17, 1937. Test discontinued.

Almirante, Panama submerged April 16, 1936—1 log. Heavy attack August 17, 1937. Test discontinued.

Arsenious Sulphide (with added gelatine)

Newport, R. I. submerged September 3, 1936. Heavy attack April 30, 1938. Test discontinued.

This material proved to be ineffective as a preservative to control marine borer activity.

Boliden Treatment.—exposed to marine borer attack.

The first series prepared in Sweden, were submerged in January 1938 at Almirante, Panama. These were lost in a heavy storm in September 1939. A second series, prepared in Duxbury, Mass., under the direction of the inventor, were submerged at Newport, R. I., on May 29, 1941. No trace of marine borer activity could be found when these tests were examined on October 31, 1941. Test continued.

Dampex.—exposed to marine borer attack.

4 Douglas fir timbers 4 in. by 4 in. by 4 ft.
2 Southern yellow pine timbers 4 in. by 4 in. by 4 ft.

Almirante, Panama—submerged May 30, 1939. Destroyed by marine borers July 3, 1940. Test discontinued.

Pentachlorophenol.—in fuel oil exposed to marine borer attack.

35 pine blocks 4 in. by 4 in. by 6 in. retention ranging from 0.37 to 1 lb. of toxic per cu. ft.

Newport, R. I.—submerged August 27, 1937. Severe attack, principally by teredo September 1939. Test discontinued.

Almirante, Panama—4 pine blocks 4 in. by 4 in. by 6 in. Submerged June 13, 1938. Riddled by teredo August 1941. Test discontinued.

Celcure.

New Bedford, Mass.—Two, 5 ft. pine logs submerged August 1935. Transferred to Newport, R. I. May 1936.

Newport, R. I.—Two additional 5 ft. pine logs submerged May 1936. All four logs were lost during the hurricane of September 1938; were found and resubmerged May 1, 1940. The last inspection on October 1941 showed a dense marine growth but no trace of any marine borer attack. Controls showed moderate attack. Test continued.

Newport, R. I.—24 Southern yellow pine sapwood sticks 2, 4, 6, and 12 percent solutions. Retentions of toxic of from approximately 0.5 to 4.0 lb. per cu. ft. Submerged April 1, 1940. On October 31, 1941, showed heavy marine growth but no evidence of marine borer attack. Controls showed heavy attack. Test continued.

Almirante, Panama.—A duplicate of the series above. Submerged November 18, 1938.

2 percent solution, average retention 0.5 lb. per cu. ft. of toxic, all showed moderate teredo attack November 1, 1939.

4 percent solution, average retention of 1.25 lb. per cu. ft. of toxic. Three samples showed no attack, the others from 1 to 40, small teredo—November 1, 1939.

6 percent solution, average retention 2.0 lb. per cu. ft. of toxic. Three samples showed no attack, one slight attack, one with one small teredo and one with one limnoria—November 1, 1939.

12 percent solution, average retention 4.0 lb. per cu. ft. of toxic. Three samples showed no attack and three very slight borer attack—November 1, 1939.

All controls destroyed. Test discontinued.

CUPRINOL.—Dip Treatment.

Sixteen, 2 in. by 4 in. by 16 in. sticks, 8 of which were treated with green and 8 with clear Cuprinol. Exposed to marine borer attack at Almirante, Panama, on June 25, 1937. All had been destroyed by marine borers by January 8, 1938. Test discontinued.

CHEMONITE.—Seven southern yellow pine logs, 7 ft. in length and 9 in. in diam. treated by the manufacturer.

Exposed to fungus, termites and marine borer attack at Almirante, Panama, on February 13, 1937. The two specimens exposed to fungus attack, and the two exposed to termite activity showed no deterioration in October 1941. The two specimens exposed to marine borers showed, in October 1941, about one teredo per sq. in. of surface, all small. Test discontinued.

One hundred twenty test sticks, 1 in. by 3 in. by 18 in., treated by the manufacturer were exposed at Almirante, Panama, August 11, 1937; 40 specimens exposed to fungus attack; 40 to termite activity and 40 to marine borer attack. Because of storms or accidents, approximately half of the series were lost. Of the 25 test specimens remaining in the marine borer tests, approximately half showed attack varying from light to heavy. All of the controls were badly attacked by the organisms to whose attack they were exposed. Test discontinued.

Tropical Timbers

GREENHEART.—6 in. by 6 in. by 18 in. blocks. Received from the Greenheart Lumber Co.

Five blocks were exposed to marine borer attack at Newport, R. I. on May 29, 1936. In October 1941 showed only a few scattered limnoria tunnels on the faces.

Three blocks exposed to marine borer attack at the Boston & Albany docks in East Boston in 1934, showed some slight evidence of a few empty limnoria tunnels on October 29, 1941.

One block submerged at Bourne, Mass. in 1938 showed, when examined on October 31, 1941, two to three limnoria per sq. in. of surface and a few small teredo navalis. Tests continued.

MANBARKLAK

6 in. by 6 in. by 4 in. submerged at New Bedford, Mass., June 21, 1938.
6 in. by 6 in. by 4 in. submerged at Bourne, Mass., November 17, 1938.
4 in. by 4 in. by 2 in. submerged at Hyannis, Mass., December 21, 1938.

None of these specimens, exposed to marine borer attack, showed any trace of attack. Test discontinued.

Two 12 in. by 12 in. by 6 ft. timbers submerged at the Boston & Albany docks in East Boston in 1934. About 3 to 4 limnoria per sq. in. were found on two edges and a few in the faces on October 29, 1941. Test continued.

AZOBE

Three 12 in. by 6 in. by 1 in. test blocks submerged at Newport, R. I., on May 29, 1936, when examined on October 31, 1941, showed slight attack by limnoria in the ends. Test continued.

Creosote

The following creosote tests are under observation:

Five squared timbers treated with low residue, high napthalene oil with a retention of about 24 lb. per cu. ft.

One submerged at Pier 46, Charlestown, Mass., in 1934
One submerged at Pier 2, Portland, Me., in 1934
Three submerged at pier, Newport, R. I., May 1936

(The last three had previously been submerged at New Bedford, Mass., for two years)

Very slight traces of limnoria attack could be seen in the specimens at Charlestown, Mass., and Portland, Maine, on October 28, 1941. The specimens at Newport showed no attack on October 31, 1941. Tests continued.

Forty Southern yellow pine logs, approximately 5 ft. in length and 8 in. in diameter, 20 of which were treated with a creosote oil with a residue above 355 deg. C. of 50 percent, and 20 with a residue of 20 percent. Submerged at Almirante, Panama, on October 22, 1940. An inspection on August 24, 1941 showed no marine borer attack.

A similar series, but treated with high and low residue oils with somewhat different characteristics has been carefully prepared, half of which will be submerged at Almirante, Panama, and the other half at Woods Hole, Mass.

Creosote—Creosote-Coal Tar—Coal Tar Series

Thirty southern yellow pine logs of the standard size used in other tests and treated 10 with creosote, 10 with 50:50 creosote-coal tar mixture and 10 with coal tar.

This series was submerged at Newport, R. I., on May 29, 1936. Because of the hurricane of 1938, these tests were out of the water from September 1939 until May 1940 when they were resubmerged. Inspected in October 1941,—none showed any trace of marine borer activity. Controls had been badly damaged.

Creosoted Douglas Fir

Twelve specimens of Douglas fir logs of the standard size used in other tests, treated with creosote having a residue above 355 deg. C., of approximately 25 percent, and with an average retention of about 12 lb. per cu. ft. were submerged at Newport, in 1936. This series was lost in the hurricane of 1938. A new series has now been prepared and is being submerged at the testing station at Woods Hole, Mass.

Creosote—Creosote-Coal Tar—Coal Tar Series

Prepared under the direction of Dr. Hermann von Schrenk. Submerged at the Boston & Albany docks, East Boston, Mass., on October 1937. Examination of test pieces made by Mr. A. Spector of the New York Central and Mr. A. P. Richards of the W. F. Clapp Laboratories on October 29, 1941. The blocks were mounted on planks of Greenheart and Manbarklak.

Plank No. 1.—Greenheart.—Several Metridium, many Molgula and Corophium. Few Anomia, Tubularia and Balanus. Heavy growth of Botryllus schlosseri. No definite evidence of limnoria tunnels was noted.

A total of twenty 2 in. by 4 in. blocks treated with distillate creosote show limnoria activity at the outer corners. This averages two to three tunnels per corner. The tunnels start at the end and extend along the face and sides of the blocks. Living limnoria were removed from Block 8–5–1.

Plank No. 2.—Manbarklak.—Growth same as Plank No. 1. Limnoria have been active on the sides to the extent of there being an average of three to four tunnels per sq. in. on these surfaces. However, the original sides had not been planed smooth. A few scattered tunnels in the face.

A total of ten 50:50 creosote-coal tar mixture blocks show no evidence of limnoria. In ten other blocks treated with distillate creosote, inspection showed a few limnoria in the corners.

Plank No. 3.—Greenheart.—Same as Plank No. 1. Out of a total of 20 blocks treated with 50:50 creosote-coal tar mixture, 16 showed no evidence of limnoria, 2 showed possible limnoria tunnels and one contained a single limnoria.

Plank No. 4.—Manbarklak with untreated control blocks was lost.

Plank No. 5.—Greenheart.—Growth somewhat lighter than Planks No. 1 and No. 3 but consisting of some organisms. A total of 20 planks treated with coal tar showed no evidence of limnoria.

Plank No. 6.—Manbarklak.—Same as Plank No. 2. Of ten blocks treated with coal tar, eight showed no limnoria; while two disclosed limnoria in one corner. Of ten untreated controls, two could not be found. All of the others were badly attacked by limnoria, and about 60 of the original blocks had been destroyed.

The absence of limnoria in Greenheart when compared with Manbarklak may be due to the fact that the Greenheart had been planed smooth while the Manbarklak had small areas of bark and sap through which most of the attack occurred. It may be of some interest to note that the coal-tar treated pieces seemed to some extent more resistant than the pieces with other treatments. A large series of similar tests at other locations may soon throw some light on the comparative values of the three types of preservative.

Gunnite Protection

Two test piles protected with a coating of Gunnite were driven beneath the General Electric wharf at Lynn, Mass., in 1935. On November 10, 1941, one pile was pulled and examined. The cement covering on steel wire averaged one inch or slightly more in diameter. After six years' service the coating is in excellent condition and has provided complete protection against any marine borer attack. There are, however, several factors which should be considered in estimating the value of this type of protection.

Handling.—This particular test pile had not been subjected to hard driving. It is possible that under usual driving conditions, the coating would have shown more evidence of having been damaged. Since even precast, air-seasoned, concrete piles are sometimes badly cracked during driving, it is very probable that this type of cement coating would not stand up under ordinary driving conditions.

Pile Top Protection.—Gunnite protection would only be used on untreated piling. In the test pile examined, this protection extended from just below the mud line to a few inches below the top. It could not be used on a pile top before driving and could not be recommended as a later application to protect the pile top from rots. It would be difficult to prevent the accumulation of moisture at the point at the top of the pile where the Gunnite stopped. This would result in pile top decay.

Harbors in Tropical Waters.—In many harbors in tropical or semi-tropical waters, the so-called rock borers, pholads, etc. rapidly destroy either neat cement or poor concrete. Good sand and gravel is necessary in a concrete capable of resisting attack by these borers. The coating on the test pile examined does not appear to be of a consistency that could be depended upon to provide protection from the rock borers.

New England Marine Piling Investigation

The test board research under the direction of Mr. W. F. Cummings, has continued.

Corner Brook, Newfoundland.—At the wharves of the Bowater Paper Co., 12 test boards are operated. There has been a gradual decrease in marine borer activity during the past two years. The last test boards examined were removed from the water on September 2, 1941. These showed a very slight limnoria attack and no trace of any teredo. Teredo were present in several of the test boards at the same time in 1940. The indications are that there is a continued decrease in marine borer activity at this location. From 1932 to 1934 an exceptionally heavy teredo attack destroyed many piles in these structures.

Liverpool, N. S.—Eleven test boards operated by the Mersey Paper Co. A severe attack by teredo navalis damaged a large number of piles in 1932. No teredo set has occurred since that year, but limnoria have been active every year. Test boards removed on September 25 showed a slight increase in limnoria over that of the previous year.

At both of the above locations, all replacements have been made with heavily creosoted material.

Calais, Maine.—Test boards operated since 1934 have all failed to show marine borer attack, undoubtedly due to constant low salinity.

Eastport, Maine.—In 1937 limnoria were very active in the test boards. There has been a gradual decrease since that year from 1600 per sq. ft. to 10 or less.

Machiasport, Maine.—No marine borers.

Machias, Maine.—No borers in 1941.

Bucksport, Maine.—No marine borers have been found in the test boards.

Searsport, Maine.—Sprague Coal Co. (untreated timber wharf) limnoria attack in 1941 not as severe as in previous years. Possibly due to extensive repairs. From 1937 to 1940 inclusive, teredo have been active. None have been found in the 1941 test boards.

Boston, Mystic River.—Limnoria attack in the test boards has shown a gradual increase since 1935, being most severe in 1941.

Boston Harbor.—The very large series of test boards in Boston Harbor continued to show a very destructive attack by limnoria and in some locations, chelura. There had been a gradual increase in the numbers of these organisms until 1938 with the census remaining approximately the same in later years.

Quincy, Mass.—Test boards show that limnoria continue very active. Chelura is confined to restricted areas. Teredo are comparatively rare and, excepting in one or two locations, have caused no measurable damage.

Scituate, Mass.—Limnoria were very active in the test boards from 1934 to 1939. There has been a definite decrease in attack in 1940 and 1941. Slight teredo attack appeared in 1934, 1936, 1937, 1939 and 1940.

Plymouth, Mass.—Limnoria are active and destructive with no annual variation in numbers. Teredo sets have occurred each year since 1935 with the exception of 1938, and possibly 1941.

Sandwich, Mass.—A light limnoria attack in 1934 increased in intensity until 1937 with a gradual decrease, until in 1941 most of the boards have shown no limnoria. Teredo attack has been consistently severe at this location since 1934.

Provincetown, Mass.—Limnoria are moderately active and have shown no marked variation since 1935. Chelura are plentiful. Teredo are present in destructive numbers, but the attack is not as severe as in the harbors on the outside of Cape Cod.

Truro, Mass.—Teredo navalis have been active and destructive during the past seven years. Limnoria, while occasionally present, are very scarce.

Chatham, Mass.—Limnoria attack very similar to that at Scituate, Mass., with a considerable attack in 1936, 1937, and 1938, with a remarkable gradual decrease in the last three years. In 1935, chelura appeared in the test boards; but none have been found in later years.

Hyannis, Mass.—There has been a consistently very destructive teredo navalis attack in the test boards since 1934, specimens frequently growing more than one inch in length per month. Limnoria attack much less severe in 1940 and 1941 than in 1939.

Woods Hole, Mass.—Teredo navalis, limnoria, and chelura are all very plentiful at this location. At a new testing station established this year, one-inch boards submerged in the latter part of July 1940, were found to have been eaten through, principally by limnoria, on November 17.

Bourne, Mass.—Only slight traces of limnoria occasionally appear in the test boards. Very destructive teredo attack has occurred each year since 1934.

Marion, Mass.—Limnoria have shown a decrease in 1939, 1940, and 1941. The teredo attack is more severe in this harbor than in any other that has been investigated on the New England Coast. 2 in. by 4 in. test boards are completely destroyed in two months. Large untreated ropes are also destroyed by teredo in a very few months.

New Bedford, Mass.—Test boards have shown a heavy attack by limnoria since 1934. Teredo are also destructive and chelura present.

Fall River, Mass.—Limnoria attack has been very light in test boards operated since 1937, but the teredo have been very plentiful and destructive at the test location.

Edgartown, Mass.—Teredo have been present in the test board each year since 1938. The set of 1940 was much more severe than in the previous years. Limnoria have been exceptionally destructive every year and chelura plentiful.

Tiverton, R. I.—Teredo navalis very destructive. All 6 in. by 4 in. by 4 in. test boards are completely riddled in four or five months. Limnoria are rarely found. In the fall of 1938 and 1939, a few (less than one to the sq. in. of surface) were found, but in the last 20 blocks examined since May 1940, 12 have not shown any trace of limnoria and the rest but 2 or 3 specimens.

Newport, R. I.—The marine borer activity is similar to that at Woods Hole, Mass., excepting that teredo navalis is not present in as destructive numbers.

Providence, R. I.—Teredo navalis is now plentiful on both sides, as far up the harbor as the site of the old Wilkesbarre pier. It is most remarkable that at Kettle Point, E. Providence, where the test boards have shown a fairly heavy attack by teredo navalis since 1936, not one specimen of limnoria has been found.

Mystic, Conn.—Limnoria are very plentiful and destructive, and chelura plentiful. The teredo attacks in 1939 and 1940 were more destructive than in previous years, but in 1941 (for the first time since 1936) no teredo have been found in the test boards.

Allyn's Point, Conn.—Teredo navalis are present in destructive numbers and sets have occurred in 1941. No limnoria or chelura have been reported.

Shaw's Cove.—Limnoria present and very destructive. Chelura are also plentiful and teredo present, but not in destructive numbers.

Niantic, Conn.—Limnoria have generally been present, but comparatively few in the test blocks since 1934, rarely more than one per sq. in. of surface. Test blocks are riddled with teredo navalis and a heavy set has occurred in 1941.

Saybrook, Conn.—In spite of the low salinity at this location, sets of teredo have appeared every year in the test boards. In 1940 the blocks were destroyed and many specimens two inches or more in length were found in the test blocks submerged during the summer of 1941. No limnoria or chelura have been found at this location since the tests were started in 1934.

Guilford, Conn.—Teredo present each year in very destructive numbers. No chelura and limnoria have been recorded since 1934.

New Haven, Conn.—Limnoria are now present in destructive numbers. In 1934 and 1935 only traces were found on the test blocks. Since 1936 there has been a remarkable increase in this species. Teredo navalis appeared for the first time in the test boards in the summer of 1937. In each succeeding year they have become more plentiful, and in 1940 were very destructive. The set of 1941 is even heavier than in previous years.

Devon, Conn.—No trace of any marine borer has been found in the test boards operated since 1934.

Bridgeport, Conn.—Conditions vary greatly in different portions of the harbor. Teredo are present in test boards in certain portions of the harbor but boards in other locations have shown no trace of marine borers.

Searsport, Maine.—Bangor and Aroostook (creosoted pile wharf). Attack similar to that above.

Rockland, Maine.—Limnoria attack similar to or somewhat heavier than that of previous seven years. Teredo have not appeared in the test boards since 1937.

Thomaston, Maine.—Teredo were present in the 1940 test boards in August. None have been found in the 1941 series up to October 9.

Wiscasset, Maine.—Limnoria activity is less than in the three previous years.

Bath, Maine.—No borers in 1941.

Portland, Maine.—Six test boards. From 1937 to 1940 teredo appeared in the test boards. None have been found in the 1941 series, and there has been a decrease in the number of limnoria in the 1941 test boards.

Scarboro, Maine.—A few teredo appeared in test boards in 1939. No limnoria since the boards were installed in 1934.

Portsmouth, N. H.—Teredo appeared in test boards in 1937 and one or two specimens in 1939. The limnoria attack has been severe from 1934 to the present time.

Newburyport, Mass.—No borers have ever appeared in any test boards.

Gloucester, Mass.—Test boards have shown a moderate limnoria attack with only slight variation since 1938.

Manchester, Mass.—Limnoria are active in the test boards. In July 1941, Xirphaea crispata, a pholad mollusc generally drilling in hard clay or peat, was found plentifully boring into concrete bridge foundations. The concrete was exceptionally poor in the area attacked.

Beverly, Mass.—Teredo were found in many test boards in 1939. None in 1940 or 1941. Limnoria attack has been consistently heavy.

Lynn, Mass.—Saugus River. There has been a marked increase in limnoria attack in 1941, 20 or 30 times greater than in the years from 1938 to 1940, inclusive. Teredo were present in 1939, but none have appeared since.

So. Norwalk, Conn.—Limnoria have never been found in the test boards in the harbor. But the destruction due to teredo navalis is greater than in any other harbor on the Connecticut Coast where investigations have been conducted.

Pelham Bay, N. Y.—A few limnoria and teredo have been found at intervals in the test boards since 1934.

Unfortunately the investigation conducted by the State of Connecticut was discontinued in 1940. The data obtained from these test boards proved to be of exceptional value, and it is hoped that in 1942 test boards may be operated again at some of the more important locations.

New York Investigation

The studies of the conditions of the waters in and around New York are being continued. In 1940, teredo and limnoria were found in locations where their presence had not been suspected. In 1941, it appears that the activity of these species has been considerably lessened at these locations. It is expected that a progress report on the study of the conditions in this area will be soon issued by the Marine Borer Research Committee of New York Harbor.

Pile Top Protection

Many methods and materials have been and are being used to provide protection against deterioration in timber pile tops. The form of protection used has depended to some extent upon the type of exposure and the species of timber.

Piles beneath structures are generally more or less protected from the weather by girders, or caps, and decking; but service records have indicated that proper protection for any pile cut-offs will greatly lengthen the serviceable life of the pile.

Foundation piles buried in fill with the cut-offs above the permanent water table are susceptible to attack by destructive organisms. In recent years, lack of proper protection for such piles has resulted in many very costly failures.

The tops of dolphin, fender, and bulkhead piles are exposed to conditions even more conducive to rapid deterioration than those which are more or less protected by superstructures or fill.

At Lynn, Mass., a bulkhead supported by several thousand Southern yellow pine piles which had been given a 12-lb. treatment of Grade 1 creosote, was built in 1929. When inspected in 1939, 50 percent of the piles were found to have been so badly damaged by rots that extensive repairs were necessary. A large proportion had been completely destroyed from the top down to the high water mark, a distance of ten feet, in less than ten years. This means that the destruction progressed at the average rate of at least one ft. per year. It is obvious that almost equally good service might be expected from untreated piling. In a similar nearby structure, untreated piles failed from the same cause and to the same extent in approximately five years.

Untreated fender and dolphin piles are occasionally used in locations where mechanical damage is so severe that the use of treated timbers may not be warranted. Unless proper protection for these pile tops is provided, deterioration will be rapid.

Most of the destruction in pile tops is due to infestations of one or more of the numerous species of fungi which cause timber rots. These organisms thrive best where moisture is plentiful, temperatures comparatively high, and to some extent where protected from direct sunlight.

Some of the more common materials for protecting pile tops are, painted canvas, bitumastics, and metal caps of copper, lead, cast iron, etc.

Service records indicate that the use of these materials does not necessarily eliminate the conditions favorable for the activity of the destructive fungi. Heat is transmitted by the covering to the wood beneath, providing the necessary warmth. This heat may cause the evaporation of some of the moisture present in the pile top, but this moisture is constantly replaced by capillary action from the lower portion of the pile. The covered pile top is therefore kept constantly moist and warm, and the covering (whatever it may be) provides protection more to the fungi than to the timber.

To ensure the maximum length of life for pile tops, the most important essentials are ventilation—which will prevent the retention of moisture and heat—and a toxic preservative to control the destructive organisms. Service records indicate that application of hot coal-tar creosote to the pile cut-offs generally provides more satisfactory protection than most pile top covers. This method is also far less expensive in spite of the fact that the creosote must be renewed at intervals.

Cast Iron Fender Tops

The following report has been received from Mr. A. F. Blake of the Atlantic Sugar Refineries, St. John, N. B.:

> The cast iron caps were attached to the fender tops during the summer of 1935. Since that time about a dozen caps were broken by accidents of one kind

or another and had to be replaced. In every instance we found that the end wood, where protected by the cap, remained in excellent condition.

There are several features which contribute their share toward the good preservation of the tops of these wooden fenders:

1. The tops of fenders were carefully fitted to suit curvature of caps.
2. The turned-down edges of cap provided a good seal for the joint and retained the wood preservative.
3. Tops of fenders were well coated with creosote and residue from creosote bath which is rich in napthalene, after which the wood was coated with a weatherproof caulking compound which filled in the voids between the cap and top of wooden fender.

Judging from our past experience, the top ends of the wooden fenders would have been destroyed by decay in about three years had not the cast iron caps been provided.

The damaged caps were destroyed chiefly by a fouling of the ships' mooring lines and revisions to the design of the caps finally overcame this trouble.

In every instance the small lugs on the side of the cast iron caps fractured before the lag screws would draw through the end wood of fender, providing ample proof that the top of the fender remained in a healthy condition.

Australian Investigation

(See AREA Proceedings, Vol. 34, p. 450; Vol. 40, p. 491)

A very intensive investigation on problems associated with various marine boring organisms has been continuously conducted in Australian waters since 1927. A Supplementary Report No. 2 has now been published by the Maritime Services Board of New South Wales. (Destruction of Timber by Marine Organisms in the Port of Sydney—Maritime Services Board of New South Wales, July 17, 1941) The results obtained in this investigation may be briefly summarized as follows:

1. In the Port of Sydney, marine borers concentrate their attack at levels near the low water mark (page 16). Concentration of attack at this level is not common in harbors on the Atlantic and Gulf Coasts of this country. In many of our harbors the most severe attack is near the mud line at depths of 30 ft. or more below M.L.W. In some locations, attack is more evident near the low water mark because waves and tides remove fragments of the damaged wood, producing the characteristic hour-glass effect. Examination of sections of timber in deeper water frequently shows that while the pile may appear to be in better condition, because it has not been subjected to abrasion by waves and floating objects, the deterioration has been equally severe. It is for this reason that there are comparatively few harbors on our coasts where the "Floating Collar" method of protection, used in Australia, can be used.

2. In the Port of Sydney, one location may be entirely free from limnoria activity; while at another, limnoria may be very destructive. Yet these locations may be but two miles apart. The danger of arriving at hasty conclusions on the general distribution of limnoria in any one port is pointed out. (page 18)

3. "—they (Bankia) seem always to show a preference for the higher levels of any timber samples immersed in the Port of Sydney." (page 19)

This observation has been found to be equally true in this country. Observations indicate that the species of teredo in which the embryo of necessity has a prolonged free-swimming period of three or four weeks, that the larvae generally float near the surface of the water and attack is concentrated in that area. This is true not only of bankia but of some teredo such as teredo dilatata, megotara, and sigerfoosi.

4. "Numerous check measurements secured on the proved basis (see Suppl. Report No. 1, 1936, p. 22) of relation of Cobra* age to the diameter of the bore hole, established the reliability of this basis of determination." (page 19)

To determine the age of an individual teredo from the diameter or length of the tunnel is impossible in any of our harbors. Every harbor on the Atlantic and Gulf coasts has a definite breeding season, very similar to that of the oyster.

* Any species of the Teredinidae including such genera as Teredo ss., Bankia, Nausitora, Lyrodus, etc.

In Boston, Mass., test blocks placed in the water at weekly intervals beginning on September 15, and continued until the following June 15, are always entirely free from any attack by teredo navalis. Embryonic teredo navalis will enter blocks submerged on July 1. By September 1, these individuals, if not stunted due to overcrowding or for other reasons, will have grown to a length of four or five inches in the two months which have elapsed. Test blocks placed in the water at the end of August will also be entered by embryonic teredo. These may soon attain a length of $\frac{1}{16}$ to ¼ in., but a period of retarded development appears to take place. In the following spring these specimens will still invariably be $\frac{1}{16}$ in. to ¼ in. in length with a known age of six months or more.

This has been found to be true in scores of harbors from Newfoundland to Port Aransas, Tex., excepting that as one proceeds south, the duration of the breeding season is lengthened and period of retarded development is shortened. In our harbors, the diameter and length of the tube of teredo depends upon whether the individual entered the wood at the beginning, in the middle, or at the end of the breeding season.

5. "Experiments on Cobra borer mortality—effects of fresh water" (page 21)

From these experiments it is stated that limnoria do not survive for more than 9 to 12 hours in fresh water, and that it takes a minimum of ten days' immersion in fresh water to kill all Cobra borers other than the brackish or fresh water species such as Nausitora.

6. "The positive results of critical experiments have now borne out a recent conclusion arrived at after close field observation, that *Chelura* has no standing as a timber boring pest." (page 34)

In harbors on our Atlantic Coast, there is a definite period of the year during which limnoria attack wood. At New London, Conn., test blocks having an exposed surface of approximately 128 sq. in. have been submerged at monthly intervals since 1934. In the eight years this test has been conducted, not one limnoria has been found in any test block submerged for one month, in January, February, March, April or May. In the blocks submerged in June, one in 1938 contained two limnoria, and one in 1939 had 41. But in July, August, September and October, limnoria occurred in every block each year, varying in number from 100 to 800 per block. In the November blocks the number is greatly reduced, and no limnoria have occurred in any of the tests submerged for the month of December. There is, therefore, a definite period of migration to new wood from July to October.

Chelura also has definite period of migration to and from timber. At the same station in New London, Connecticut, chelura have rarely been found in any timbers or test blocks, regardless of the length of time submerged, during the months of March, April, May, June or July. They are only present regularly and in numbers from October to February.

It is possible that these seasons of migration of limnoria and chelura have been responsible for the reputation chelura has acquired as a wood borer. Being present during certain months, almost to the exclusion of limnoria, has led to the belief that the damage to the timber must have been due to chelura. The Australian studies indicate that its destructive activity has been greatly exaggerated.

7. Sea water fungi is causing deterioration of hardwoods (page 36) "These show that some timbers are weakened by a softening of the surface fibers to a depth of ¼ in. of true wood in a period of seven years of immersion."

Studies in this country have shown innumerable cases of this fungus deterioration both in test blocks and in piling. The rate of destruction, while somewhat greater than that recorded above, is so slight that it has little effect on the life of a timber. But recent observations indicate that this type of timber deterioration may possibly be beneficial. Test blocks submerged beneath a wharf near Stapleton, Staten Island, have invariably for several years been badly damaged each summer by teredo navalis. It was believed that such a heavy attack must have resulted in some damage to the bearing piles of the wharf. In a recent inspection, samples were taken from a large number of the piles at varying depths and none showed any trace of teredo. An examination of the samples and of the piling showed that the samples of the timber had been damaged to a depth of from $\frac{1}{16}$ to ⅛ in., by marine fungi. The surface of the wood had been reduced to soft shiny pulp. It is conceivable that the embryos would have as great difficulty in drilling through this material as they would through soft mud. At present, no other reason can be offered for the immunity of these piles in the presence of severe teredo attack.

8. "Floating Collar Process for Wharf Pile Preservation" (page 45) "Expansion of the treatment method in recent years embraces the preservation of some 40,000 piles in Port Jackson (Port of Sydney) at an approximate cost of ten pence per pile per annum for labour and material."

It is unfortunate that there are comparatively few harbors on our coast where this method could be successfully used, since it only provides protection for the between tide section of the pile.

Report on Assignment 4

Effect of Preservative Treatment by the Use of Creosote-Petroleum, and Zinc Chloride and Petroleum

R. P. Hughes (chairman, subcommittee), G. B. Campbell, W. R. Goodwin, L. B. Holt, R. S. Hubley, M. F. Jaeger, A. J. Loom, T. H. Strate, W. A. Summerhays.

Your committee presents the following report as information with the recommendation that the subject be discontinued.

The work done by your committee on the above subject since it was first assigned may be summarized as follows:

The first report was submitted in 1924 after a year and a half of study and research into the history of the use of creosote and petroleum mixtures in the United States and abroad. This report also included information obtained by the committee on three inspections of creosote-petroleum mixture ties at various points on the Atchison, Topeka & Santa Fe, particularly as to the length of service given by these ties.

In 1925, after the committee had again made an inspection of 975 creosote-petroleum mixture ties in the Cleveland, Tex., test section of the Santa Fe, a report was submitted giving the life of these ties to date.

There was also included in this report, the description of a process developed at the Mellon Institute of Industrial Research, Pittsburgh, Pa., by means of which zinc chloride and petroleum were injected into the timber in the form of an emulsion composed of zinc chloride 15 to 40 percent strength, and a mixture of heavy asphaltic-base petroleum thinned to desired viscosity by means of gas oil or petroleum distillate. The report gave results to date from these ties as well as service life of zinc-petroleum ties treated by the two-movement process.

In 1926, the committee reported progress, as little change had occurred in the ties theretofore inspected.

The next report was in 1928 and was a continuation of the study of the creosote-petroleum ties in the Cleveland test section, the committee having again inspected these ties in 1927. This report included a number of tables in which a comparison was shown between various groups of these ties as to kinds of wood, pounds of creosote per cubic foot of timber, pounds of mixture per cubic foot of timber, and kinds of mixture. A report was also made in 1928 of results obtained from the zinc-petroleum and straight zinc-chloride ties in the Cleveland test section. This report was a comparison showing the superiority of the zinc chloride-petroleum treatment over the straight zinc chloride treatment of ties under similar conditions.

The 1930 report covered the results of an inspection by the committee, of creosote-petroleum mixture treated ties on the Slaton and Pecos divisions of the Santa Fe, and

(text continued on page 461)

The Atchison, Topeka and Santa Fe Railway Company.

Tabulation Showing Actual Performance to January 1, 1941, in Track, and Estimated Total Life Based on Tie-Life Curve of the Forest Products Laboratory at Madison, Wisconsin, of Ties in Test Tracks of the Santa Fe Railway, Treated with Creosote-Petroleum Mixture, zinc Chloride, Creosote and Petroleum, and Zinc Chloride and Petroleum, and for Comparison, Ties Treated with Straight Creosote.

Year In-serted	Original Number Inserted	Total Removed	Perdent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Sawn Western Yellow Pine Ties. Treatment, 10 to 12 Lbs. per Cu.Ft. 30/70 Creosote-Petroleum Mixture.				
1910	2,266	907	40.03	26.08	35.29
1911	2,259	944	41.79	22.32	33.33
1912	145	97	66.90	18.24	26.67
Total	4,670	1,948	41.71		
	Hewn and Sawn Western Yellow Pine Ties. Treatment, 7 Lbs. Per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1912	119	42	35.29	23.46	34.15
1913	9,395	957	10.19	25.62	42.86
1914	712	149	20.93	23.64	35.62
1915	730	347	47.53	22.13	27.47
1922	1,581	60	3.80	17.75	*
1923	2,097	61	2.91	16.94	*
1924	1,148	53	4.62	15.80	*
1925	1,461	33	2.26	14.81	*
Total	17,243	1,702	9.87		
	Hewn and Sawn Southern Yellow Pine Ties. Treatment, 7 Lbs. per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1922	601	37	6.16	17.72	*
1923	2,251	101	4.49	16.85	*
Total	2,852	138	4.84		
	Hewn and Sawn Red Oak Ties. Treatment, 7 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1922	1,967	188	9.56	17.71	28.57
1923	801	69	8.61	16.84	*
Total	2,768	257	9.28		

#Based on Forest Products Laboratory Curve.
*Percent Renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn White Oak Ties. Treatment, 7 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1922	400	80	20.00	17.75	25.00
1923	400	46	11.50	16.78	26.15
Total	800	126	15.75		
	Hewn and Sawn Gum Ties. Treatment, 7 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1922	1,992	36	1.81	17.97	*
1923	188	5	2.66	16.86	*
Total	2,180	41	1.88		
	Hewn and Sawn Red Gum Ties. Treatment, 7 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1923	777	19	2.45	16.04	*
	Hewn and Sawn Black Gum Ties. Treatment, 7 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1923	544	5	0.92	16.95	*
	Sawn Pacific Coast Douglas Fir Ties. Treatment 7 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1921	501	21	4.19	18.83	*
1922	5,263	1,131	21.49	17.14	24.66
1923	6,845	1,193	17.43	16.15	24.29
1924	2,274	163	7.17	15.80	*
1925	209	19	9.09	14.67	*
1926	267	3	1.12	13.99	*
Total	15,359	2,530	16.47		
	Hewn and Sawn Rocky Mountain Fir Ties. Treatment 7 Lbs. Per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1923	201	4	1.99	16.99	*
1924	68	1	1.47	15.99	*
Total	269	5	1.86		

Based on Forest Products Laboratory Curve.
* Percent Renewed is Beyond the Limits of the Forest Products Laboratory Curve.

Year Inserted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn White Fir Ties. Treatment, 7 Lbs. Per Cu.Ft. 50/50 Creosote-Petroleum Mixture				
1922	200	16	8.00	17.83	*
1923	198	48	24.24	15.99	22.67
Total	398	64	16.08		
	Hewn and Sawn Magnolia Ties. Treatment, 7 Lbs. Per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1923	200	11	5.50	16.95	*
1925	99	0	0.00	15.00	*
1926	105	0	0.00	14.00	*
Total	404	11	2.72		
	Hewn and Sawn Cottonwood Ties. Treatment, 7 Lbs. Per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1923	150	0	0.00	17.00	*
	Sawn Beech Ties. Treatment, 7 Lbs. Per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1923	200	3	1.50	16.96	*
	Hewn and Sawn Southern Yellow Pine Ties. Treatment 7 Lbs. per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	54,773	2,481	4.53	16.90	*
1924	4,257	509	11.96	15.47	24.62
1925	1,576	198	12.56	14.51	22.73
1926	2,692	89	3.31	13.89	*
Total	63,298	3,277	5.18		
	Hewn and Sawn Western Yellow Pine Ties. Treatment 7 Lbs. per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	737	123	16.69	16.23	24.29
	Hewn and Sawn Oak Ties. Treatment, 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	1,043	203	19.46	16.39	23.94

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year Inserted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn Red Oak Ties. Treatment, 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	764	31	4.06	16.88	*
	Hewn and Sawn White Oak Ties. Treatment, 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	399	37	9.27	16.84	*
	Hewn and Sawn Gum Ties. Treatment 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	4,475	543	12.13	16.68	26.15
1924	999	115	11.51	15.26	24.62
1925	91	7	7.69	15.00	*
1926	343	0	0.00	14.00	*
Total	5,908	665	11.26		
	Sawn Red Gum Ties. Treatment, 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	802	32	3.99	16.89	*
	Sawn Black Gum Ties. Treatment, 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	400	0	0.00	17.00	*
	Sawn Pacific Coast Douglas Fir Ties. Treatment 7 Lbs. per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	101	10	9.90	16.48	26.98
	Hewn and Sawn White Fir Ties. Treatment, 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	332	32	9.64	16.70	26.98
	Hewn and Sawn Magnolia Ties. Treatment, 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	363	12	3.31	16.84	*

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Sawn Beech Ties. Treatment 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	187	4	2.14	16.94	*
	Sawn Bay Ties. Treatment, 7 Lbs. Per Cu.Ft. 70/30 Creosote-Petroleum Mixture.				
1923	194	3	1.55	16.95	*
	Hewn and Sawn Southern Yellow Pine Ties. Treatment 8 Lbs. per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1924	9,221	295	3.20	15.97	*
1925	6,454	214	3.32	14.86	*
1926	8,330	324	3.89	13.83	*
1927	18,805	597	3.17	12.90	*
1928	21,741	350	1.61	11.96	*
1929	47,753	124	0.26	11.00	*
1930	14,972	177	1.18	9.97	*
Total	127,276	2,081	1.64		
	Hewn and Sawn Oak Ties. Treatment 8 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1924	603	87	14.43	15.64	23.88
1925	446	75	16.82	14.51	21.43
1926	333	44	13.21	13.52	21.21
1927	172	1	0.58	12.99	*
1928	986	15	1.52	11.98	*
1929	1,003	65	6.48	10.85	*
1930	2,576	19	0.74	9.99	*
Total	6,119	306	5.00		
	Hewn and Sawn Gum Ties. Treatment 8 Lbs. Per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1924	374	15	4.01	15.88	*
1925	1,346	79	5.87	14.67	*
1926	4,252	257	6.04	13.77	*
1927	579	61	10.54	12.76	20.31
1928	2,067	190	9.19	11.73	*
1929	2,469	48	1.94	10.97	*
1930	3,402	20	0.59	9.99	*
Total	14,489	670	4.62		

#Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the F.P.Lab. Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Sawn Beech Ties. Treatment, 8 Lbs. Per Cu.Ft. 50/50 Creosote-Petroleum Mixture.				
1925	101	5	4.95	15.00	*
	Hewn Elm Ties. Treatment, 8 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1925	99	0	0.00	15.00	*
1926	103	3	2.91	13.97	*
Total	202	3	1.49		
	Hewn Bay Ties. Treatment, 8 Lbs. Per Cu. Ft. 50/50 Creosote-Petroleum Mixture.				
1925	99	1	1.01	13.92	*
1926	99	2	2.02	14.98	*
Total	198	3	1.52		
	Hewn and Sawn Southern Yellow Pine Ties. Treatment, 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture.				
1924	505	14	2.77	15.97	*
1925	1,363	4	0.29	14.99	*
1927	210	1	0.48	13.00	*
1928	2,444	3	0.12	12.00	*
1930	603	0	0.00	10.00	*
Total	5,125	22	0.43		
	Hewn and Sawn Western Yellow Pine Ties. Treatment, 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture.				
1924	714	13	1.82	15.90	*
1925	1,041	69	6.63	14.86	*
1926	3,746	19	0.51	13.98	*
1927	4,353	53	1.22	12.92	*
1928	7,853	52	0.66	11.97	*
1929	5,217	33	0.63	10.98	*
1930	6,433	35	00.54	10.00	*
Total	29,357	274	0.93		

Based on Forest Products Laboratory Curve.
* Percent Renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Sawn Western Yellow Pine Ties. Treatment, 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture, Steamed 2 Hours 20 Lbs. Pressure.				
1928	1,771	15	0.85	11.99	*
1929	55	0	0.00	11.00	*
Total	1,826	15	0.82		
	Sawn Western Yellow Pine Ties. Treatment, 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture, Steamed 2 Hours 30 Lbs. Pressure.				
1928	1,817	13	0.72	11.99	*
	Hewn and Sawn Gum Ties. Treatment, 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture.				
1924	98	0	0.00	16.00	*
	Sawn Pacific Coast Douglas Fir Ties. Treatment 8 Lbs. per Cu.Ft. 45/55 Creosote-Petroleum Mixture				
1924	1,144	91	7.95	15.42	*
1925	2,558	82	3.21	14.84	*
1926	10,821	223	2.06	13.92	*
1927	6,674	84	1.26	12.96	*
1928	9,290	45	0.48	11.99	*
1929	18,790	70	0.37	11.00	*
1930	8,702	87	0.99	9.98	*
Total	58,069	682	1.17		
	Hewn and Sawn Rocky Mountain Fir Ties. Treatment 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture.				
1925	194	9	4.64	14.92	*
1927	2,919	45	1.54	12.94	*
1928	2,942	32	1.09	11.99	*
1929	389	3	0.77	10.99	*
1930	580	0	0.00	10.00	*
Total	7,024	89	1.27		

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn Corkbark Fir Ties. Treatment, 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture.				
1927	245	27	11.02	12.73	20.31
	Sawn Magnolia Ties. Treatment, 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture.				
1926	99	3	3.03	13.92	*
	Hewn and Sawn Balsam Ties. Treatment, 8 Lbs. Per Cu.Ft. 45/55 Creosote-Petroleum Mixture.				
1926	351	7	1.99	13.97	*
	Hewn Southern Yellow Pine Ties. Treatment, 8 Lbs. Per Cu.Ft. 25/75 Creosote-Petroleum Mixture.				
1924	980	5	0.51	15.99	*
1925	1,057	0	0.00	15.00	*
1929	1,011	86	8.51	10.83	*
1930	974	19	1.95	9.96	*
Total	4,022	110	2.73		
	Hewn and Sawn Western Yellow Pine Ties - Treatment 8 Lbs. per Cu.Ft. 25/75 Creosote-Petroleum Mixture.				
1924	995	3	0.30	15.99	*
1928	3,639	91	2.50	11.96	*
1929	1,147	26	2.27	10.92	*
Total	5,781	120	2.08		
	Sawn Western Yellow Pine Ties. Treatment, 8 Lbs. Per Cu.Ft. 25/75 Creosote-Petroleum Mixture, Steamed 2 Hours 20 Pounds Pressure.				
1928	1,832	63	3.44	11.95	*
	Sawn Western Yellow Pine Ties. Treatment, 8 Lbs. Per Cu.Ft. 25/75 Creosote-Petroleum Mixture, Steamed 2 Hours 30 Pounds Pressure.				
1928	1,829	41	2.24	11.97	*

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year Inserted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn Gum Ties. Treatment, 8 Lbs. Per Cu. Ft. 25/75 Creosote-Petroleum Mixture.				
1925	515	0	0.00	15.00	*
	Hewn and Sawn Southern Yellow Pine Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture, Two-Movement.				
1922	575	153	26.61	17.41	23.38
1923	967	411	42.50	15.78	19.54
Total	1,542	564	36.58		
	Hewn and Sawn Western Yellow Pine Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture, Two-Movement.				
1922	1,698	219	12.90	17.80	27.27
1923	941	46	4.89	16.88	*
1926	6,665	45	0.68	13.98	*
Total	9,304	310	3.33		
	Hewn and Sawn Red Oak Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture Two-Movement.				
1922	800	449	56.13	16.62	18.75
1923	424	141	33.25	16.66	20.99
Total	1,224	590	48.20		
	Hewn and Sawn White Oak Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture - Two-Movement.				
1922	394	244	61.93	16.63	17.82
1923	141	59	41.84	15.59	19.54
Total	535	303	56.64		
	Hewn and Sawn Gum Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture-Two-Movement.				
1922	800	37	4.63	17.88	*
1923	777	65	8.37	16.83	*
Total	1,577	102	6.47		

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the F.P.Lab. Curve.

Year Inserted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Sawn Pacific Coast Douglas Fir Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture, Two-Movement.				
1922	999	935	93.59	12.66	*
1923	300	168	56.00	15.17	17.71
Total	1,299	1,103	84.91		
	Hewn Rocky Mountain Fir Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture, Two-Movement.				
1922	200	69	34.50	17.08	21.95
1923	200	2	1.00	16.95	*
Total	400	71.	17.75		
	Sawn Beech Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture - Two-Movement.				
1923	196	16	8.16	16.78	*
	Sawn Magnolia Ties. Treatment, 1/2 Lb. Zinc Chloride Plus 5 Lbs. 30/70 Creosote-Petroleum Mixture-Two-Movement.				
1923	208	17	8.17	16.94	*
	Hewn Southern Yellow Pine Ties. Treatment, 1/4 Lb. Dry Zinc Chloride and 8 Lbs. Petroleum. Zinc Chloride Solution and Petroleum in Emulsion - One-Movement.				
1925	626	142	22.68	14.66	20.27
1926	197	4	2.03	13.94	*
Total	823	146	17.74		
	Hewn Southern Yellow Pine Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 8 Lbs. Petroleum. Zinc Chloride Solution and Petroleum in Emulsion - One-Movement.				
1925	681	147	21.59	14.48	20.55
1926	146	20	13.70	13.64	20.90
Total	827	167	20.19		

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn Southern Yellow Pine Ties. Treatment, 3/4 Lb. Dry Zinc Chloride and 8 Lbs. Petroleum. Zinc Chloride Solution and Petroleum in Emulsion - One-Movement.				
1925	593	126	21.25	14.64	20.55
1926	227	24	10.57	13.82	21.88
Total	820	150	18.29		
	Hewn Oak Ties. Treatment, 1/3 Lb. Dry Zinc Chloride and 8 Lbs. Petroleum. Zinc Chloride Solution and Petroleum in Emulsion - One-Movement.				
1925	221	98	44.34	13.16	17.05
	Hewn Gum Ties. Treatment, 2/3 Lb. Dry Zinc Chloride and 8 Lbs. Petroleum. Zinc Chloride Solution and Petroleum in Emulsion - One-Movement.				
1925	230	27	11.74	14.63	23.08
	Hewn and Sawn Southern Yellow Pine Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1922	591	341	57.70	15.91	18.37
1923	800	251	31.38	16.43	21.25
1924	313	98	31.31	15.31	20.00
Total	1,704	690	40.49		
	Hewn and Sawn Western Yellow Pine Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1922	1,398	172	12.30	17.90	27.69
1923	802	60	7.48	16.82	*
Total	2,200	232	10.55		
	Hewn and Sawn Red Oak Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1922	800	486	60.75	15.68	18.00
1923	390	189	48.46	15.83	18.68
1924	208	131	62.98	13.86	15.84
Total	1,398	806	57.65		

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn White Oak Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1922	399	202	50.63	16.34	19.35
1923	200	139	69.50	14.62	15.89
Total	599	341	56.93		
	Hewn and Sawn Gum Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1922	779	359	46.08	15.90	20.22
1924	296	79	26.69	15.37	20.78
Total	1,075	438	40.74		
	Hewn and Sawn Red Gum Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1923	383	27	7.05	16.64	*
	Sawn Black Gum Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1923	191	0	0.00	17.00	*
1924	272	73	26.84	15.39	20.78
Total	463	73	15.77		
	Sawn Pacific Coast Douglas Fir Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1922	988	916	92.71	11.33	*
1923	200	100	50.00	14.86	18.48
Total	1,188	1,016	85.52		
	Hewn Rocky Mountain Fir Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1922	401	122	30.42	17.67	22.78
	Sawn Beech Ties. Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1923	199	32	16.08	16.72	24.64

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Sawn Magnolia Ties - Treatment, 1/2 Lb. Dry Zinc Chloride and 5 Lbs. Petroleum - Two-Movement.				
1923	200	10	5.00	17.96	*
	Hewn and Sawn Western Yellow Pine Ties - Treatment, 1/2 Lb. Dry Zinc Chloride and 8 Lbs. Petroleum - Two-Movement.				
1926	2,543	8	0.31	13.99	*
	Hewn and Sawn Southern Yellow Pine Ties - Treatment, 5 Lbs. Creosote - Rueping.				
1904	1,452	1,444	99.45	22.49	*
1905	2,000	1,914	95.70	17.37	*
1906	43,683	42,527	97.35	21.52	*
1907	19,075	18,461	96.78	18.58	*
1908	24,313	23,264	95.69	20.55	*
1909	18,381	17,221	93.69	18.44	*
1910	90,664	63,816	70.39	24.83	28.04
1911	15,355	9,839	64.08	23.76	28.43
1912	11,417	9,049	79.26	21.82	24.35
1913	273,259	106,821	39.09	25.06	32.14
1914	31,521	20,190	64.05	19.97	25.49
1915	5,257	4,208	80.05	17.69	21.55
1916	4,565	2,311	50.62	20.69	25.81
1917	19,494	15,320	78.59	20.69	20.00**
1918	11,233	6,368	56.69	18.87	22.68
1919	15,189	3,925	25.84	19.00	27.63
1920	2,939	1,627	55.36	16.05	20.83
1921	2,727	1,093	40.08	16.84	22.35
1922	8,417	2,974	35.33	16.04	21.95
1923	5,266	1,331	25.28	15.87	22.37
1924	363	74	20.39	15.31	22.22
1925	105	26	24.76	13.95	19.74
Total	606,675	353,803	58.32		
	Hewn and Sawn Western Yellow Pine Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1908	1,435	1,341	93.45	18.76	*
1909	5,337	4,593	86.06	21.54	25.41
1910	3,581	3,330	92.99	19.01	*

(This table continued on following page, No. 14)

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the F.P. Lab. Curve.
** Exp. Ave. Life based on F.P. Curve less than actual life.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn Western Yellow Pine Ties. Treatment, 5 Lbs. Creosote-Rueping (Con't from Page No. 13)				
1911	2,437	2,292	94.05	11.20	*
1912	680	601	88.38	16.14	22.58
1913	1,711	1,293	75.57	19.46	24.11
1914	2,569	1,443	56.17	20.40	27.08
1915	377	222	58.89	19.37	25.51
1916	4,409	1,786	40.51	21.37	27.91
1917	5,234	2,506	47.88	20.77	25.27
1918	455	200	43.96	19.54	25.00
1920	2,267	235	10.37	19.47	31.75
1921	312	89	28.53	17.86	24.36
1922	2,081	195	9.37	17.57	*
1923	765	26	3.40	16.90	*
1930	1,076	3	0.28	9.98	*
Total	34,726	20,155	58.04		
	Hewn and Sawn Oak Ties. Treatment, 5 Lbs. Creosote-Rueping.				
1906	113	112	99.12	21.52	*
1909	3,286	2,969	90.35	21.60	24.60
1910	4,570	4,253	93.06	20.39	*
1911	4,784	4,582	95.78	20.58	*
1912	2,346	1,678	71.53	21.93	25.69
1913	1,444	1,327	91.90	21.14	*
1914	2,070	1,318	63.67	21.77	25.49
1915	1,737	969	55.79	19.81	26.04
1916	3,866	2,441	63.14	20.25	23.76
1917	3,602	1,676	46.53	19.99	25.56
1918	1,842	914	49.62	20.26	23.91
1919	673	545	80.98	14.20	17.95
1920	173	84	48.55	15.99	21.98
1921	116	73	62.93	18.50	18.91
1922	912	488	53.51	16.68	18.95
1923	1,436	559	38.93	15.34	20.24
1924	933	144	15.43	15.38	23.53
1925	227	33	14.54	14.42	22.06
Total	34,130	24,165	70.80		

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn Red Oak Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1907	51	51	100.00	15.87	*
1911	504	361	71.63	25.80	26.61
1913	314	200	63.69	24.54	26.47
1917	4,334	3,958	91.32	21.90	*
1918	2,758	372	13.49	21.70	33.33
1922	1,354	185	13.66	17.72	26.87
1923	792	36	4.55	14.00	*
Total	10,107	5,163	51.08		
	Hewn and Sawn White Oak Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1911	377	305	80.90	24.42	24.79
1922	400	10	2.50	17.96	*
1923	391	35	8.95	16.93	*
Total	1,168	350	29.97		
	Hewn and Sawn Gum Ties. Treatment, 5 Lbs. Creosote-Rueping.				
1907	2,282	2,100	92.02	22.58	*
1908	842	629	74.70	22.66	28.83
1909	1,763	641	36.36	27.25	37.35
1910	13,088	2,410	18.41	29.42	42.86
1911	2,589	1,744	67.36	23.16	27.62
1912	380	326	85.79	20.61	22.95
1913	904	720	79.65	21.65	23.28
1914	2,683	1,702	63.44	23.13	25.74
1917	817	265	32.44	21.35	28.75
1918	678	409	60.32	17.13	22.22
1920	855	345	40.35	17.26	23.53
1921	1,921	600	31.23	18.16	23.75
1922	4,073	784	19.25	17.27	25.35
1923	1,426	256	17.95	16.25	24.29
1924	194	44	22.68	14.97	21.62
1926	310	0	0.00	14.00	*
Total	34,805	12,975	37.28		

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn Red Gum Ties. Treatment, 5 Lbs. Creosote-Rueping.				
1923	802	52	6.48	16.89	*
1924	102	5	4.90	15.83	*
Total	904	57	6.31		
	Hewn and Sawn Black Gum Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1923	386	10	2.59	16.90	*
	Sawn Pacific Coast Douglas Fir Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1910	12,999	12,887	99.14	16.79	*
1911	271	268	98.89	15.59	*
1915	1,972	1,076	54.56	22.74	26.04
1916	1,650	777	47.09	21.14	26.67
1920	735	102	13.88	19.60	29.85
1921	422	55	13.03	18.26	28.79
1922	1,365	280	20.51	17.54	24.66
1923	459	40	8.71	16.36	*
Total	19,873	15,485	77.92		
	Hewn and Sawn Rocky Mountain Fir Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1923	200	7	3.50	16.97	*
1928	1,910	64	3.35	11.98	*
1930	538	0	0.00	10.00	*
Total	2,648	71	2.68		
	Hewn White Fir Ties. Treatment, 5 Lbs. Creosote-Rueping.				
1923	200	5	2.50	16.99	*
	Sawn Beech Ties. Treatment, 5 Lbs. Creosote-Rueping.				
1911	307	139	45.28	25.04	32.95
1912	1,921	1,289	67.10	23.87	26.67
1923	200	33	16.50	16.85	24.29
Total	2,428	1,461	60.17		

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn Balsam Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1926	369	1	0.27	13.98	*
	Hewn and Sawn Cottonwood Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1923	150	2	1.33	16.87	*
	Hewn Ash Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1907	240	240	100.00	18.14	*
	Sawn Bay Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1923	201	18	8.96	16.64	*
	Sawn Magnolia Ties. Treatment, 5 Lbs. Creosote - Rueping.				
1923	398	33	8.29	16.58	*
1925	86	4	4.65	15.00	*
Total	484	37	7.64		
	Hewn and Sawn Southern Yellow Pine Ties. Treatment, 7 Lbs. Creosote - Rueping.				
1922	600	130	21.67	17.71	24.66
1923	523	36	6.88	16.77	*
Total	1,123	166	14.78		
	Hewn and Sawn Western Yellow Pine Ties. Treatment, 7 Lbs. Creosote - Rueping.				
1922	1,591	63	3.96	17.89	*
1923	800	44	5.50	16.89	*
1924	197	7	3.55	15.96	*
Total	2,588	114	4.40		
	Hewn and Sawn Red Oak Ties. Treatment, 7 Lbs. Creosote-Rueping.				
1922	1,190	80	6.72	17.84	*
1923	31,197	1,064	3.41	16.92	*
Total	32,387	1,144	3.53		

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond limits of F.P. Lab. Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Hewn and Sawn White Oak Ties. Treatment, 7 Lbs. Creosote - Rueping.				
1922	391	98	25.06	17.73	23.68
1923	200	52	26.00	16.55	22.37
Total	591	150	25.38		
	Hewn and Sawn Gum Ties. Treatment, 7 lbs. Creosote - Rueping.				
1922	1,194	104	8.71	17.77	*
	Hewn and Sawn Red Gum Ties. Treatment 7 Lbs. Creosote - Rueping.				
1923	770	34	4.42	16.90	*
	Hewn and Sawn Black Gum Ties. Treatment, 7 Lbs. Creosote - Rueping.				
1923	400	9	2.25	16.93	*
	Sawn Pacific Coast Douglas Fir Ties. Treatment, 7 Lbs. Creosote - Rueping.				
1922	1,000	291	29.10	17.80	23.08
1923	200	1	0.50	16.99	*
Total	1,200	292	24.33		
	Sawn Beech Ties. Treatment, 7 Lbs. Creosote - Rueping.				
1923	190	10	5.26	16.68	*
	Hewn White Fir Ties. Treatment, 7 Lbs. Creosote-Rueping.				
1923	200	1	0.50	16.96	*
	Hewn Rocky Mountain Fir Ties. Treatment, 7 Lbs. Creosote - Rueping.				
1923	198	9	4.55	16.75	*

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond limits of Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-41	Expected Average Life #
	Sawn Bay Ties. Treatment, 7 Lbs. Creosote - Rueping.				
1923	200	3	1.50	16.88	*
	Sawn Magnolia Ties. Treatment, 7 Lbs. Creosote-Rueping.				
1923	400	13	3.25	16.93	*

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.

[1]The A. T. and S. F. Ry. Co., Office Manager Treating Plants, System, Topeka, Kansas, November 24, 1941.

Reading Company

Tabulation Showing Actual Performance to Sept. 27, 1941, in Track, and Estimated Total Life Based on Tie-Life Curve of the Forest Products Laboratory at Madison, Wisconsin, of Ties in Test Tracks of the Reading Company, Treated with Creosote-Gas oil Mixture, and Creosote-Petroleum Mixture.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 9-27-41	Expected Average Life #
	Hewn Sap Pine Ties. Treatment, 10 Lbs. per Cu. Ft. +30/70 Creosote-Gas Oil Mixture - Full Cell.				
[1]1925	100	14	14.00	15.70	23.88
	Sawn Birch, Beech and Maple Ties. Treatment, 9.90 Lbs. Per Cu. Ft. 30/70 Creosote-Gas Oil Mixture - Full Cell.				
1925	100	1	1.00	15.99	*
	Hewn and Sawn Red Oak Ties. Treatment, 8.69 Lbs. Per Cu. Ft. 30/70 Creosote-Gas Oil Mixture - Full Cell.				
[1]1925	100	0	0.00	16.00	*
	Hewn Sap Pine Ties. Treatment, 9.77 Lbs. Per Cu. Ft. 30/70 Creosote-Petroleum Mixture - Full Cell.				
1925	100	0	0.00	16.00	*
	Sawn Birch, Beech and Maple Ties. Treatment, 9.52 Lbs. Per Cu. Ft. 30/70 Creosote-Petroleum Mixture - Full Cell.				
[1]1925	101	2	1.98	15.99	*
	Sawn Red Oak Ties. Treatment, 9.44 Lbs. Per Cu. Ft. 30/70 Creosote-Petroleum Mixture - Full Cell.				
1925	100	0	0.00	16.00	*

Based on Forest Products Laboratory Curve.
* Percent renewed is beyond the limits of the Forest Products Laboratory Curve.
+ When stating the percentage of creosote-petroleum mixtures, in this report, the percentage of creosote is given first.

Northern Pacific Railway Company

Tabulation Showing Actual Performance to January 1, 1942, in Track, and Estimated Total Life Based on Tie-Life Curve of the Forest Products Laboratory at Madison, Wisconsin, of Ties in Test Tracks of the Northern Pacific Railway Company, Treated with Creosote, Creosote-petroleum Mixture, and Untreated.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-42	Expected Average Life#
	Ties Placed Out-of-Face Near Grassy Point, Duluth				
	Hewn and Sawn White Oak Ties - Untreated.				
1922	100	83	83.00	14.29	16.24
	Hewn and Sawn Birch Ties - Treatment, 6.25 Lbs. Creosote - Lowry.				
1922	98	0	0.00	19.00	*
	Hewn and Sawn Birch Ties - Treatment, 7 Lbs. 50/50 Creosote-Petroleum Mixture - Lowry.				
1922	101	0	0.00	19.00	*
	Hewn and Sawn Maple Ties - Treatment, 6.25 Lbs. Creosote - Lowry.				
1922	101	3	2.97	18.97	*
	Hewn and Sawn Maple Ties - Treatment, 7 Lbs. 50/50 Creosote-Petroleum Mixture - Lowry.				
1922	100	3	3.00	18.94	*
	Hewn and Sawn Red Oak Ties - Treatment, 6.25 Lbs. Creosote - Lowry.				
1922	100	0	0.00	19.00	*
	Hewn and Sawn Red Oak Ties - Treatment, 7 Lbs. 50/50 Creosote-Petroleum Mixture - Lowry.				
1922	100	0	0.00	19.00	*

Based on Forest Products Laboratory Curve.
* Percent Renewed is beyond the limits of the Forest Products Laboratory Curve.

Year In-serted	Original Number Inserted	Total Removed	Percent Removed	Average Life In Track to 1-1-42	Expected Average Life#
	Ties Placed Out-of-Face near Plateau, Montana.				
	Hewn and Sawn White Oak Ties - Untreated.				
1923	120	120	100.00	10.50	*
	Hewn and Sawn Birch Ties. Treatment - 6.25 Lbs. Creosote - Lowry.				
1923	101	0	0.00	18.00	*
	Hewn and Sawn Birch Ties. Treatment - 7 Lbs. 50/50 Creosote-Petroleum Mixture - Lowry.				
1923	100	0	0.00	18.00	*
	Hewn and Sawn Maple Ties. Treatment - 6.25 Lbs. Creosote - Lowry.				
1923	101	0	0.00	18.00	*
	Hewn and Sawn Maple Ties. Treatment - 7 Lbs. 50/50 Creosote-Petroleum Mixture - Lowry.				
1923	101	10	9.90	17.6	28.57
	Hewn and Sawn Red Oak Ties. Treatment - 6.25 Lbs. Creosote - Lowry.				
1923	100	0	0.00	18.00	*
	Hewn and Sawn Red Oak Ties. Treatment - 7 Lbs. 50/50 Creosote-Petroleum Mixture - Lowry.				
1923	99	0	0.00	18.00	*

Based on Forest Products Laboratory Curve.
* Percent Renewed is beyond the limits of the Forest Products Laboratory Curve.

(text continued from page 449)
showed a comparison between the performance of these ties and ties treated with 5 lb. of straight creosote, and with straight zinc chloride treated ties. The report also included details of an inspection of ties in the Kingman, Ariz., test of the Santa Fe.

In 1939 a report was submitted giving performance records of approximately one million ties in test tracks of the Northern Pacific, the Reading, and the Atchison, Topeka & Santa Fe. Of these, approximately 222,000 were creosote-petroleum mixture ties, 15,000 were ties treated with zinc chloride-petroleum, 16,000 were ties treated with zinc chloride, creosote and petroleum; and for comparison, there were included results from 790,000 ties treated with straight creosote, most of these treated with 5 lb. per cu. ft., but a considerable portion treated with 7 lb. straight creosote per cu. ft.

These tabulations showed actual average life in track to date, and also the expected average life reflected by the Forest Products Laboratory curve, for all groups in which the number of ties renewed lay between 10 percent and 90 percent. Beyond these limits, the use of the curve is not recommended by the Forest Products Laboratory. The ties were separated as to kinds of wood and as to variations in the percentage of creosote in the mixture, and the net retention per cubic foot of the preservative.

This year your committee has brought up to date the performance records of the approximately one million ties in the test tracks of the Northern Pacific, the Reading, and the Santa Fe, and is submitting a statement showing the average life in track to date of these ties, and the expected average life reflected by the Forest Products Laboratory curve, for all groups in which the number of ties renewed lies between 10 and 90 percent. The ties have been separated as to kinds of wood, various percentages of creosote in the mixture, and as to net retention per cubic foot of the preservative.

Report on Assignment 5

Destruction by Termites and Possible Ways of Prevention

Hermann von Schrenk (chairman, subcommittee), W. F. Clapp, E. A. Craft, John Foley, A. M. Knowles, F. B. Robins, W. A. Summerhays.

This report is presented as information with the recommendation that the subject be continued.

The committee has little to report on termites this year except to state that the termites are continuing their activities. A number of reports have been received from various sections of the country indicating failures which may be due to the type of chemical applied as well as to workmanship. Again we point out the necessity for careful investigation principally of points of possible entrance in structures where untreated timber is in contact with the ground, and we stress the desirability of using creosoted lumber where possible. No cases of destruction by termites in wood treated with creosote by the full-cell process have come to the attention of the subcommittee.

The termite exposure test pieces at Florissant, Mo., have been left undisturbed. The past summer was so very dry that the termites retreated to deeper positions in the ground where apparently sufficient moisture might be obtained. This was indicated by the fact that untreated control pieces buried throughout the field were not attacked by termites.

The subcommittee submits the following notes which were obtained in connection with reports received by the subcommittee on Piling Used for Marine Construction from the Almirante, Panama, testing station:

Pentachlorphenol.—Pine blocks, 4 by 4 by 6 in., were treated with Pentachlorphenol and exposed to termite and fungus attack at the Almirante, Panama, testing station in November, 1939. They showed no attack on October 20, 1941. All controls were completely destroyed. Test continued.

Celcure.—18 southern yellow pine sapwood sticks were treated with 1, 2, and 4 percent solutions of Celcure and exposed to termite attack at the Almirante, Panama, testing station on November 18, 1938. They were examined in August 1941, with the following results:

1-percent solution: Average retention of 0.33 lb. toxic per cu. ft. Of the 6 sticks, 3 showed slight termite attack.

2-percent solution: Average retention of 0.66 lb. per cu. ft. Of the 6 sticks, 4 showed slight termite attack.

4-percent solution: Average retention of 1.33 lb. per cu. ft. Of the 6 sticks, 2 showed slight termite attack and 2 some fungus attack.

Controls: Badly attacked. Test discontinued.

In an identical series exposed to attack by destructive fungi at Almirante, Panama, none of the treated specimens showed deterioration to fungi while all controls had been badly attacked. Test discontinued.

Cuprinol.—16 sticks, 2 by 4 by 16 in., were dipped in Cuprinol. Eight were treated with green Cuprinol and 8 with clear Cuprinol. They were exposed to termite attack at Almirante, Panama, on June 25, 1937. By January 8, 1938, they had been so badly damaged by termites that the test was abandoned.

Chemonite.—2 southern yellow pine logs, 7 ft. long and 9 in. in diameter, were treated with Chemonite by the manufacturer and exposed to termite attack on February 13, 1937, at Almirante, Panama. Two similar specimens were exposed to fungus attack at the same time. None of the specimens showed any deterioration in October 1941. Tests discontinued.

Chemonite.—80 sticks, 1 by 3 by 18 in., were treated with Chemonite by the manufacturer and exposed at Almirante, Panama, on August 11, 1937. Forty specimens were exposed to termite attack and 40 to fungus attack. Approximately half were lost, but 24 specimens remaining in the fungus testing ground in October 1941, showed no trace of attack. The 7 sticks remaining in the termite tests also showed no attack in October 1941. All controls were badly attacked in both cases. Tests discontinued.

Report on Assignment 6

Specifications for the Preservative Treatment of Pacific Coast Douglas Fir

R. S. Belcher (chairman, subcommittee), W. P. Arnold, S. J. Buckman, H. E. Horrocks, R. S. Hubley, A. J. Loom, O. C. Steinmayer, Hermann von Schrenk.

The Specifications for the Treatment of Pacific Coast Douglas Fir which follow are recommended for inclusion in the Manual to supersede Specifications for the Preservative Treatment of Douglas Fir, pages 17–47 to 17–55, and Specifications for the Treatment of Air-Seasoned Douglas Fir, pages 17–57 to 17–62. Your committee recommends that the subject be discontinued.

SPECIFICATIONS FOR THE PRESERVATIVE TREATMENT OF PACIFIC COAST DOUGLAS FIR

I GENERAL REQUIREMENTS

101. The following requirements (sections 102 to 109, and 301 to 604, inclusive) apply to each of the treatment processes. If these requirements are to be modified to meet special requirements, complete detailed instructions shall be given.

102. *Plant Equipment.*—Treating plants shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in acceptable, proper working condition. The apparatus and chemicals necessary for making the analyses and tests required by the purchaser shall also be provided by plant operators, and kept in condition for use at all times.

103. *Conditioning.*—Douglas fir shall be conditioned by air-seasoning, by steaming (used only when treatment is with salt preservative), or by heating in oil either under vacuum or at atmospheric pressure, or by a combination of them as agreed upon, in such a manner as will not cause injurious checking, splitting or warping.

104. Douglas fir shall be air-seasoned before treatment whenever possible, for a period sufficient to reduce to not over 20 percent the moisture content within the marginal 2 inches of round or rectangular material. In any case, the material shall be treated before it begins to decay. Air-seasoned material may be given a preliminary heating in the preservative for not more than 6 hours at a temperature of not more than 210 degrees F.

105. When steam-conditioning is used, material shall be steamed in the cylinder at not more than 240 deg. F. (approximately 10 pounds pressure per square inch) for not less than 3 hours and not more than 6 hours, which temperature maximum shall not be reached in less than 1 hour. The duration of the steaming shall be based on consideration of the shape, cross-sectional area and moisture content of the material. The cylinder shall be provided with vents to relieve it of air and insure proper distribution of steam. After steaming is completed a minimum vacuum of 22 inches at sea level shall be maintained for not less than 30 minutes or more than 60 minutes. The cylinder shall be relieved continuously or frequently enough to prevent condensation from accumulating in sufficient quantity to reach the wood. Before the preservative is introduced the cylinder shall be drained of condensate.

106. When conditioning by heating in oil is used, the oil shall cover the material in the cylinder. The temperature of the oil during the conditioning period shall not exceed 210 degrees F. for rectangular material and 220 degrees F. for round material. If a vacuum is then drawn, it shall be of sufficient intensity to evaporate the water from the material at the temperature of the oil. The intensity of the vacuum, or the temperature of the oil, or both, shall be adjusted so as to regulate the evaporation of the water satisfactorily. The conditioning shall continue until the material is sufficiently heated and enough water removed to permit proper penetration. The oil shall be removed from the cylinder before an empty-cell process is applied.

107. *Grouping for Treatment.*—Whenever it is practicable, the material in any charge shall consist of pieces similar in size, moisture content, sapwood content, and receptivity to treatment, and rectangular material so separated as to insure contact of the heating medium with all surfaces.

108. *Machining.*—So far as practicable, all adzing, boring, chamfering, framing, gaining, incising, mortising, surfacing, trimming, etc., shall be done prior to treatment.

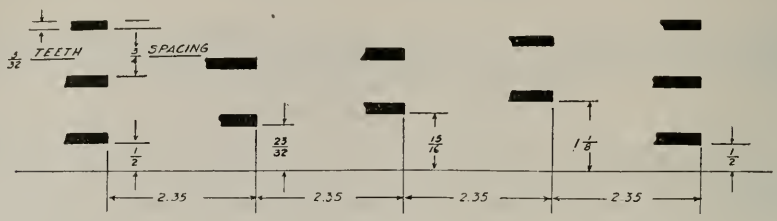


Fig. 1717.

109. *Incising.*—Except when incising will unfit lumber for the use intended, all rectangular Douglas fir shall be incised on both sides and edges, with incisor teeth not more than $\frac{5}{32}$ inch thick, to the pattern shown in Fig. 1717. In pieces 5 or more inches thick, the incisions shall be ¾ inch deep. In pieces less than 5 but more than 2 inches thick, they shall be ¾ inch deep in the edges but only ½ inch deep in the sides. Incising of pieces 2 inches and thinner is not recommended.*

II TREATMENT

Oil Treatment

201. *Manner of Treatment.* Following the conditioning period, the material shall be treated by an empty-cell process whenever practicable, to obtain as deep and uniform penetration as possible with the retention of preservative stipulated. Material shall be treated by the full-cell process only when the maximum net retention is desired and where pressure is held to refusal, or when the stipulated retention is greater than can be obtained by the use of an empty-cell process. The ranges of pressure, temperature and time duration shall be controlled so as to get the maximum penetration by the quantity of preservative injected.

STANDARD PROCESSES

Empty-Cell—Lowry and Rueping[2]

202. Material shall be subjected to atmospheric air pressure or to higher initial air pressure of the necessary intensity and duration. The preservative shall be introduced until the cylinder is filled, the air pressure being maintained during the filling operation. The pressure shall be raised to not more than 175 pounds per square inch. (This is not to be used as a continuous operating pressure. If attempted at all, it must be of brief duration. For any appreciable period, continuous pressure need not exceed 125 pounds per square inch.) Material shall be held under pressure until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by ejection of surplus preservative from expansion of the air and by a quick, high vacuum.

203. The temperature of the preservative during the entire pressure period shall be not more than 210 degrees F., but shall average at least 180 degrees F.

204. After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative. Or, after pressure is completed and before removal of the preservative from the cylinder,

* Provided they are made by incising machines constructed prior to 1940, patterns slightly different from the AREA standard are not objectionable.

[2] If the cylinder is filled at atmospheric air pressure, the process is that known as Lowry. If initial air pressures higher than atmospheric are used, the process is that known as Rueping.

the preservative surrounding the material may be reheated to a maximum of 220 degrees F., either at atmospheric pressure or under vacuum, the steam to be turned off the heating coils immediately after the maximum temperature is reached. The cylinder shall then be emptied speedily of preservative and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

205. At the completion of treatment, material may be cleaned by a final steaming at not more than 240 degrees F., for not more than 30 minutes.

Full-Cell—Bethel

206. The material shall be subjected to a vacuum of not less than 22 inches at sea level for not less than 30 minutes, either before the cylinder is filled or during the period of heating under vacuum. If not already full, the cylinder shall then be filled without first breaking the vacuum. The pressure shall be raised to not more than 175 pounds per square inch. (This is not to be used as a continuous operating pressure. If attempted at all, it must be of brief duration. For any appreciable period, continuous pressure need not exceed 125 pounds per square inch.) The material shall be held under pressure until there is obtained the volumetric injection that will insure the stipulated retention, or until the wood is treated to refusal.

207. The temperature of the preservative during the entire pressure period shall be not more than 210 degrees F., but shall average at least 180 degrees F.

208. After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

209. At the completion of treatment, material may be cleaned by a final steaming at not more than 240 degrees F., for not more than 30 minutes.

Salt Treatment

210. Salt Treatment (to be used only for treatment of ties and lumber).

211. *Manner of Treatment.*—Following the conditioning period ties and lumber shall be treated by the full-cell process. The treating solution shall be of uniform concentration and no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption practicable with the process used. The ranges of pressure, temperature and time duration shall be controlled so as to get the maximum penetration by the quantity of preservative solution injected.

STANDARD PROCESS

Full-Cell—Burnett

212. Ties and lumber shall be subjected to a vacuum of not less than 22 inches at sea level for not less than 30 minutes. The preservative solution shall be introduced until the cylinder is filled without first breaking the vacuum. The pressure shall be raised to not more than 175 pounds per square inch. (This is not to be used as a continuous operating pressure. If attempted at all, it must be of brief duration. For any appreciable period, continuous pressure need not exceed 125 pounds per square inch.) Ties and lumber shall be held under pressure until there is obtained the volumetric injection that will insure the stipulated retention, or until the wood is treated to refusal.

213. The temperature of the preservative solution during the entire pressure period shall not be sufficient to change the character of the solution.

214. After pressure is completed the cylinder shall be emptied speedily of preservative solution, and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping solution.

III RESULTS OF TREATMENT

301. *Retention of Preservative.* The net retention in any charge shall be not less than 90 percent of the quantity of preservative that may be specified; but the average retention by the material treated under any contract or order of 5 charges or more and the average retention of any 5 consecutive charges shall be 100 percent of the quantity specified. When the contract or order comprises less than 5 charges the average retention shall be not less than 95 percent of the quantity specified. The amount of preservative retained shall be calculated from readings of measuring-tank gages or scales.

302. The volume of oil preservatives shall be calculated on the basis of 100 degrees F. Calculations of volume or weight shall be made by the use of temperature or specific gravity factors contained in the volume and specific gravity correction tables of the American Railway Engineering Association.

303. The weight of salt preservatives shall be based on the dry salt, as determined by the standard methods of analysis of the AREA.

304. The amount of preservative retained shall be as follows, depending on use requirements, and as stipulated in Purchaser's order and in accordance with Section 301, in pounds per cubic feet of wood in each charge.

305. Ties and lumber for use in coastal waters and exposed to marine-borer attack; treatment shall be by the full-cell process to refusal, with not less than 12 pounds of creosote.

306. Ties and lumber not exposed to marine-borer attack, under 5 inches thick:

Not less than 10 pounds of creosote, creosote-coal tar solution, or creosote-petroleum solution.[3]

Not less than 1 pound of zinc chloride.

307. Ties and lumber not exposed to marine-borer attack, 5 inches and thicker:

Not less than 8 pounds of creosote, creosote-coal tar solution, or creosote-petroleum solution.[3]

Not less than ¾ pound of zinc chloride.

308. Piles for use in coastal waters and exposed to marine-borer attack; treatment shall be by the full-cell process to refusal, with not less than 12 pounds of creosote.

309. Piles for use on land or in fresh water:

Not less than 8 pounds of creosote.

Not less than 10 pounds of creosote-coal tar solution, or creosote-petroleum solution.[3]

310. Poles:

Not less than 8 pounds of creosote, creosote-coal tar solution, or creosote-petroleum solution.[3]

311. *Penetration.*—The penetration shall be specified by the Purchaser in accordance with use requirements, but shall be not less than the following:

[3] No standard for creosote-petroleum solution has been adopted by the Association.

312. *Ties or lumber.*—In any lot, penetration shall be not less than the following, for at least 80 percent of the pieces bored in each charge:

Thickness—Inches	*Depth—Inches*	*Percent of Sapwood*
Any, for use in marine structures	½	90
Under 5	⅜	90
5 and over	½	90

313. Piles:

Process	*Pounds per Cubic Feet*	*Depth—Inches*
Full-cell	12	¾
Full-cell	14	⅞
Full-cell	16	1
Empty-cell	8	¾
Empty-cell	10	⅞
Empty-cell	12	1

314. *Poles.*—The penetration in any pole shall be not less than ¾ inch or less than 85 percent of the sapwood if the penetration is less than 1¾ inches.

Determination of Penetration

315. *Ties.*—Penetration shall be determined by boring not less than two ties in each tram in each charge.

316. *Lumber.*—Penetration shall be determined by a sufficient number of pieces of lumber to be representative of each charge.

317. *Piles.*—Penetration shall be determined by a boring made approximately midway between the butt and top of each pile in each charge, and only the piles meeting the penetrance requirements shall be accepted.

318. *Poles.*—Penetration shall be determined by a boring made approximately midway between the butt and top of each pole in each charge, and only the poles meeting the penetrance requirements shall be accepted.

319. *Plugging Penetrance Test Holes.*—All holes made for determining penetration of preservative shall be filled with tight-fitting treated plugs.

IV PRESERVATIVES

The preservatives used shall be whichever of the following standards of this Association is stipulated:

Creosote.
Creosote-coal tar solution.
Creosote-petroleum solution.[4]
Zinc chloride.

V INSPECTION

The inspection of Douglas fir, preservatives, and treatment shall be in accordance with the standard practices of this Association.

[4] No standard for creosote-petroleum solution has been adopted by the Association.

VI RETREATMENT

601. Material not conforming to the stipulated minimum requirements may be retreated and may be re-offered for acceptance, under the following conditions:

602. The retreatable material in a charge of untreated material shall not be limited to a percent of the total quantity in the charge.

603. The standard limits for temperature of steam or preservative and for preservative pressure shall not be exceeded.

604. The amount of preservative injected during the retreatment of material shall be at the discretion of the plant operator, provided the net retention is not less than the minimum requirements.

Report of Committee 1—Roadway and Ballast

A. E. Botts, *Chairman,*
F. W. Alexander
E. J. Beugler
F. W. Biltz
Clifton Brannon
H. F. Brown
G. H. Burnette
F. W. Capp
Paul Chipman
A. P. Crosley
L. J. Drumeller
R. L. Dyke
Herbert Ensz
J. A. Given
A. T. Goldbeck
F. L. Guy
Albert Haertlein
F. W. Hillman
A. R. Jones
O. N. Lackey
H. W. Legro
E. R. Lewis
Paul McKay
G. W. Miller
W. S. Moore
C. P. Nicholson
J. A. Noble
M. C. Patton
G. W. Payne
J. M. Podmore
W. C. Pruett
A. D. Kennedy, *Vice-Chairman,*
C. S. Robinson
L. H. Roden
L. S. Rose
E. M. Smith
W. C. Swartout
Raymond Swenk
C. D. Turley
H. E. Tyrrell
Stanton Walker
G. B. Wall, Jr.
C. S. Wicker
P. H. Winchester
A. H. Woerner
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Physical properties of earth materials:

   (a) Roadbed. Load capacity. Relation to ballast. Allowable pressures.

   No report.

   (b) Foundation soils. Settlement. Moisture effects. Consolidation. Lateral flow. Bearing capacity. Piling foundations.

   Final report—submitted for adoption ..... page 471

2. Natural waterways: Prevention of erosion, check dams.

   Progress report—presented as information with the expectation of offering it later for adoption ..... page 474

3. Culverts:

   (a) Pipe line crossings—specification, for non-inflammable substances.

   Final report—submitted for adoption ..... page 481

   (b) Corrugated metal culverts, particularly types for special conditions.

   No report.

   (c) Specifications for perforated pipe for subdrainage.

   Progress report—submitted as information with the expectation of offering it later for adoption ..... page 481

   (d) Specifications for multiplate or sectional plate pipe and arches.

   Progress report—submitted as information with the expectation of offering it later for adoption ..... page 483

   (e) Vitrified clay pipe culverts—specifications.

   Final report—submitted for adoption ..... page 489

4. Formation of the roadway: Recent grading projects.

   No report.

5. Roadway drainage:
   (a) Adherence to recommended practice.

   No report.

   (b) Effect of locomotive blow offs on track maintenance, collaborating with Committee 13—Water Service, Fire Protection and Sanitation.

   Final report—submitted as information ..... page 497

6. Roadway protection:
   (a) Retaining structures:
      (1) Cribbing; timber, concrete.
      (2) Walls; dry rubble, masonry.

   Progress report—submitted as information ..... page 499

   (b) Stabilization of roadbed: report on methods used.

   No report.

7. Tunnels: Maintenance.

   Final report—submitted as information ..... page 507

8. Fences:
   (a) Corrosion-resisting fence wire, collaborating with appropriate subcommittees of Committee A-5 on Corrosion of Iron and Steel, ASTM.

   Progress report—submitted as information ..... page 509

   (b) Wood fence posts, specifications, etc.

   Final report—submitted for adoption ..... page 510

   (c) Investigate extent of use of concrete fence posts.

   No report.

   (d) Laws on right-of-way fences:
      (1) When and where required.
      (2) Kind required.

   No report.

9. Signs: Specifications and plans for telltales—overhead and side.

   No report.

10. Ballast: Report on adherence to recommended practice of cleaning foul ballast.

    No report.

11. Ballast tests: Develop relationship of ballast materials between service behavior and results obtained from Los Angeles testing machine.

    No report.

12. Special ballast: Investigate the use of asphalt in ballast.

    Progress report—submitted as information ..... page 513

The Committee on Roadway and Ballast,
A. E. Botts, *Chairman.*

Report on Assignment 1 (b)

Physical Properties of Earth Materials

Structural Bearing Power

H. W. Legro (chairman, subcommittee), E. J. Beugler, H. F. Brown, Herbert Ensz, F. L. Guy, Albert Haertlein, E. R. Lewis, Paul McKay, A. H. Woerner.

Last year your committee presented, as information, a report on Structural Foundation Soils (Proceedings for 1941, Vol. 42, pages 541 to 543, inclusive). This report with minor revisions is now submitted with the recommendation that it be adopted and published in the Manual.

106. STRUCTURAL FOUNDATION SOILS

The purpose of a foundation is to support dead and live loads upon the earth in such manner that the soil will not fail or undergo unequal deformation which would harm the structure or be otherwise objectionable.

Certain fundamental principles concerning the relation of the footing to the foundation must be observed; for example, the importance of the coincidence of the center of pressure and the center of mass of the footing. In design, the distribution of dead and live loads on the foundation depends greatly on the type of structure and nature of the loads and requires trained judgment of the engineer. Railroad engineers, besides designing structures of which the dead load may be the principal load, have to provide for heavy rolling loads on many of their structures. These matters must be taken into account in the application of soil mechanics to foundation problems.

A. SETTLEMENT

Consolidation; Lateral Flow

In respect of settlement, soils under load may be classified under two basic divisions: (a) cohesive soils which include clays and sandy clays; and (b) cohesionless soils of which sand, gravel and silt are the principal varieties. The behavior of these two classes of soils differs greatly. Clay, for example, compresses very slowly due to the slowness with which the contained moisture escapes. When a load is applied to a mass of clay, the water first takes practically all the load. Then, as the water gradually escapes under pressure, the soil skeleton composed of the clay particles carries more of the applied load. Continued application tends to break down the internal structure; consolidation takes place; and settlement of the supported load results. Plastic or lateral flow if present also contribute to settlement.

With sand, the action is quite different. Each particle transmits its share of the pressure received more directly to the adjacent particles. Consolidation is more rapid and of a smaller magnitude; and unless vibration is present, a density will be reached beyond which addition of load will have no effect until the ultimate resistance of the soil is reached. Frictional resistance to lateral flow is much greater in granular soils.

The approach to the computation of settlement in cohesive soil is not, in theory, different from the computations of deformations and deflections in a structure. The procedure is, first, compute the stresses; then, by means of the relations between stress

and deformation, compute the strains; and finally, by summation of the strains, obtain the total movement, or settlement, at the surface.

The first part, the stress distribution in soil, is determined by equations developed for the computation of stress distribution in elastic, isotropic and homogeneous solids. As soils, however, possess these properties to little degree, these computations can be approximations only but are useful if suitable allowances are made for the effects of variations in soils.

The information required for the second part, that is, the relation between stress and deformation in soil, may be obtained from laboratory tests of undisturbed samples of the soil. A comparatively simple test serves to determine the physical properties of the material for this condition. From the test, a pressure-void ratio curve is obtained by measuring change in thickness due to increments of pressure at definite intervals of time until equilibrium is reached. Thus a relation between load, time and ultimate deformation may be obtained.

Moisture Effects

While it is important to design for the distribution of loads in soil with respect to its moisture content at the time of construction, it is also important to anticipate future changes in moisture content. These may occur either by a raising or a lowering of the water table.

If the moisture content of soil in which wood piles have been driven is materially decreased, the preservative quality due to continuous submersion is lost, and piling fails from decay. When the ground water level is lowered in cohesive soils, the soil structure undergoes change; and structures with foundations designed for stability in the moisture-bearing soil are likely to settle, largely because of shrinkage of the soil mass. Granular soil, if confined, may have considerable supporting power when merely saturated, but that supporting power disappears if hydrostatic head is introduced. So-called quicksand illustrates the effect of this condition.

B. BEARING CAPACITY

Area Effects

The ratio of the depth of a foundation to its width or diameter has a marked effect on its settlement under a given unit load. In cohesionless soils, the settlement of a foundation under a given unit load is practically independent of its width for large areas and directly proportional to the width for smaller areas; while in soils having high cohesion and low internal friction, the settlement under a given unit load increases directly with the diameter of the loaded area.

Safe Loads

An assumption very commonly made is that for any given kind of soil there exists a definite safe load intensity. Safe bearing values are not based alone upon a knowledge of the properties and behavior of soils, but also upon the experience gained from observations made of existing foundations, of which as many pertinent facts as possible are known.

In the present practice of building design and construction, it is quite unlikely that ultimate bearing capacity will be reached since progressive settlement under such conditions would be excessive. Bridge piers, earth embankments, dams, dikes, cofferdams, retaining walls and other structures producing a highly concentrated load on soil are more likely to cause failure in shear, or, otherwise expressed, exceed the ultimate bearing capacity.

Field loading tests and laboratory tests have a definite place in soil mechanics; but in the absence of other information, their results may be misleading. Field loading tests are usually conducted with small-scale areas relative to the size of the foundation for the structure. As above mentioned, bearing values for large and small areas are not comparable.

Laboratory tests are valuable for measuring the physical properties of soil, but it is necessary to consider that the soil sample under test has undergone some change during the process of sampling that to some degree makes it different from the soil left undisturbed in the ground. Also it should be remembered that natural soil is not homogeneous, and laboratory measurements reveal the properties of the soil at the few spots only where the samples were taken.

Safe bearing loads for various kinds of soil as shown in even modern building codes should be used for important structures only by an experienced engineer who can evaluate the effect of the many variables of his particular problem and modify as necessary the application of tabular bearing values to his design.

Piling Foundations

The bearing capacity of piles depends on two different factors; first, the frictional resistance acting along the sides of the pile, and second, the point resistance or resistance of the soil against being compressed and displaced at the foot of the pile.

If the structure of clay is broken down during construction, by pile-driving for instance, the effect is to increase the compressibility of the foundation area. A large portion of the settlement of a foundation may be due to consolidation of the remolded soil under its own weight rather than to the load distributed by the piles into the soil.

Usual pile-driving formulas are based on the energy of blow and penetration of the pile, or a dynamic condition. What is desired is satisfactory static bearing capacity. Thus the driving formula is of value only in such cases as the dynamic resistance, or rapid penetration, is some measure of the static bearing capacity, or slow penetration. In sands, gravels and other relatively permeable, cohesionless soils, driving penetration and static-load penetration are about the same. The dynamic formula in this case may give a close approximation of the static resistance of an individual pile. In clays, silts and other relatively impermeable, cohesive soils, there is no known relation between the dynamic resistance and the static bearing capacity of piles, so that for such soils, a pile-driving formula has not been developed that contains all factors necessary to produce satisfactory results.

Comparing the penetration per blow immediately before with that after a period of rest of at least 24 hours will determine whether the material of the foundation belongs to the first or to the second class. If these two penetrations are alike, it is quite certain that the material belongs in the first class, and that a pile-driving formula can be expected to furnish fairly reliable results.

In all cases where the piles do not act strictly as columns, the summation of the bearing power of the individual piles in a foundation may not represent the bearing power of the foundation as a whole. The effect either of consolidating the soil by pile-driving or of increasing the compressibility through remolding must be considered in the light of experience.

Report on Assignment 2

Natural Waterways—Prevention of Erosion, Check Dams

L. S. Rose (chairman, subcommittee), F. W. Biltz, G. W. Miller, C. P. Nicholson, J. A. Noble, M. C. Patton, C. S. Robinson, C. D. Turley.

The following is a progress report presented as information, with the expectation of offering it later for adoption and publication in the Manual.

204. PREVENTION OF EROSION

A. REDUCTION OF GRADIENT, CHECK DAMS

The reduction of stream gradient by means of check dams as an erosion preventive is practical only where the major portion of the channel material is of such size as not to require too great a reduction in velocity to prevent transportation; where the natural slope of the stream is not so great as to make necessary a prohibitive number of check dams and where the length of channel section to be controlled falls within economic limits.

This method has proved successful under favorable conditions in preventing erosion in streams which, due to their natural slope, develop erosive velocities during periods of heavy runoff. Erosive or transporting velocities often result in the undermining of railway structures or the deposit of water-borne channel materials in the waterway opening and channel near the railway. When this occurs the waterway opening may become so reduced as to cause flooding of the tracks or a washout of the embankment or structure.

Check dams act as vertical drops or steps in the channel floor and make possible a reduction of the natural channel slope between them. The reduction in slope results in a reduction in stream velocity and the energy developed by the falling water at the drops is dissipated upon the aprons of the check dams. It is therefore possible by this means to reduce the stream velocity above the railway to one which will not transport channel materials which have formerly been deposited in the waterway opening. It would not be practical to attempt to stop the transportation of the finer materials, such as fine sand or silt which would be held in suspension through the opening.

To determine the correct channel slope two factors must be considered; first, the maximum permissible velocity of flow; second, the channel cross-section best fitting the existing physical conditions.

The maximum permissible velocity of flow can best be determined by observation and experience. While it might be impractical to attempt to determine the stream velocity while materials were being transported, it would be possible to determine the approximate velocity, during the receding stage, at which the heavier materials ceased to be transported. No rule can be expressed for determining the safe maximum velocity as it is dependent upon the size and shape of the materials and the manner in which nature has laid them down. Experience, however, has demonstrated that a mean velocity of eight feet per second with a bottom velocity of about six feet per second will not cause serious movement of ordinary creek gravel mixed in size from about one cubic inch up.

Check dams do not impound water. Therefore, a larger wetted cross-section of channel must be provided to compensate for the reduction in velocity of flow. The determination of the channel cross-section may be, in varying degree, controlled by existing conditions, both natural and man-made. Structures too expensive to enlarge may span

the stream in the reach to be controlled. If such structure dimensions fall within permissible limits they can be used as the determining factor of channel width. If not, it may be necessary to accelerate the flow at such points by providing a steeper, narrower channel, paved or in a flume to prevent erosion. In such cases it would be necessary to install baffles or a stilling pool at the foot of such a reach unless it terminates below the railway bridge.

As near as practicable, the size of the channel should be such that the excavated material will just be sufficient to bring the levees and channel bed to the desired grade line. Other factors, however, may control. For instance, as the channel width is increased, the depth for a given flow and the hydraulic radius are reduced. The reduction in hydraulic radius permits a steeper slope for an assumed maximum velocity. A steeper slope requires fewer or lower check dams to provide the necessary vertical drop but even where conditions permit, this factor has economic and physical limits—the wider the channel the longer the check dams—and there is also a tendency of the stream, during low stage flow, to cut secondary channels if the main channel is too wide for uniform flow at such stages.

Having selected for trial a practical channel width, the next step is to determine the depth of water which, at the required maximum velocity, will deliver the pre-determined flood flow. For example, a typical installation as shown in Fig. 1 is used, where the assumed mean velocity is 8 ft. per sec. and the maximum flow is 2,800 cfs. The wetted channel area then equals $\frac{2{,}800}{8}$ or 350 sq. ft.

A practical channel width is 65 ft. and it was found by trial that with side slopes of 1½ to 1, the water depth would be 4.84 ft. In some cases it may be desirable to use flatter side slopes. Using the 1½ to 1 side slopes and a water depth of 4.84 ft., the wetted side slope is 8.73 ft. and for both side slopes, plus the 65 ft. base, the wetted perimeter, P, is 82.46 ft. The wetted area, A, of the proposed channel with a depth of 4.84 ft. is 349.74 sq. ft. The hydraulic radius, $R, = \frac{A}{P}$, or in this case $\frac{349.74}{82.46}$, or $R = 4.24$.

With the hydraulic radius determined, the next step is to find the channel slope which will produce the desired velocity of 8 ft. per sec. This can be done by using the following (Kutters) formula:

$$V_m = \left\{ \frac{41.65 + \frac{1.811}{n} + \frac{0.00281}{S}}{1 + \left(41.65 + \frac{0.00281}{S}\right)\sqrt{\frac{n}{R}}} \right\} \sqrt{RS}$$

In the example given, the coefficient of channel roughness, $n, = .035$ and $R = 4.24$, as developed above. A diagrammatic solution of the formula will be of great assistance as the slope, S, in feet per foot, must be found by the trial and error method. It is found that by using 0.005 for S, the mean velocity obtained is 7.97 ft. per sec. Therefore, a slope of 0.5 percent was used, as indicated in Fig. 1.

With the required channel slope determined, the total amount of vertical drop needed to compensate for the change in channel slope is easily computed by figuring the difference in elevations attained by the existing and the proposed slopes for the length of channel to be controlled. In the example the difference between the 1.77 percent natural channel slope and the proposed slope of 0.5 percent is 1.27 percent, which for the 2,805 ft. of channel treated equals 35.6 ft. This total drop was divided into seven steps. Check dam No. 7, however, was constructed 10 ft. high so that it projected well above

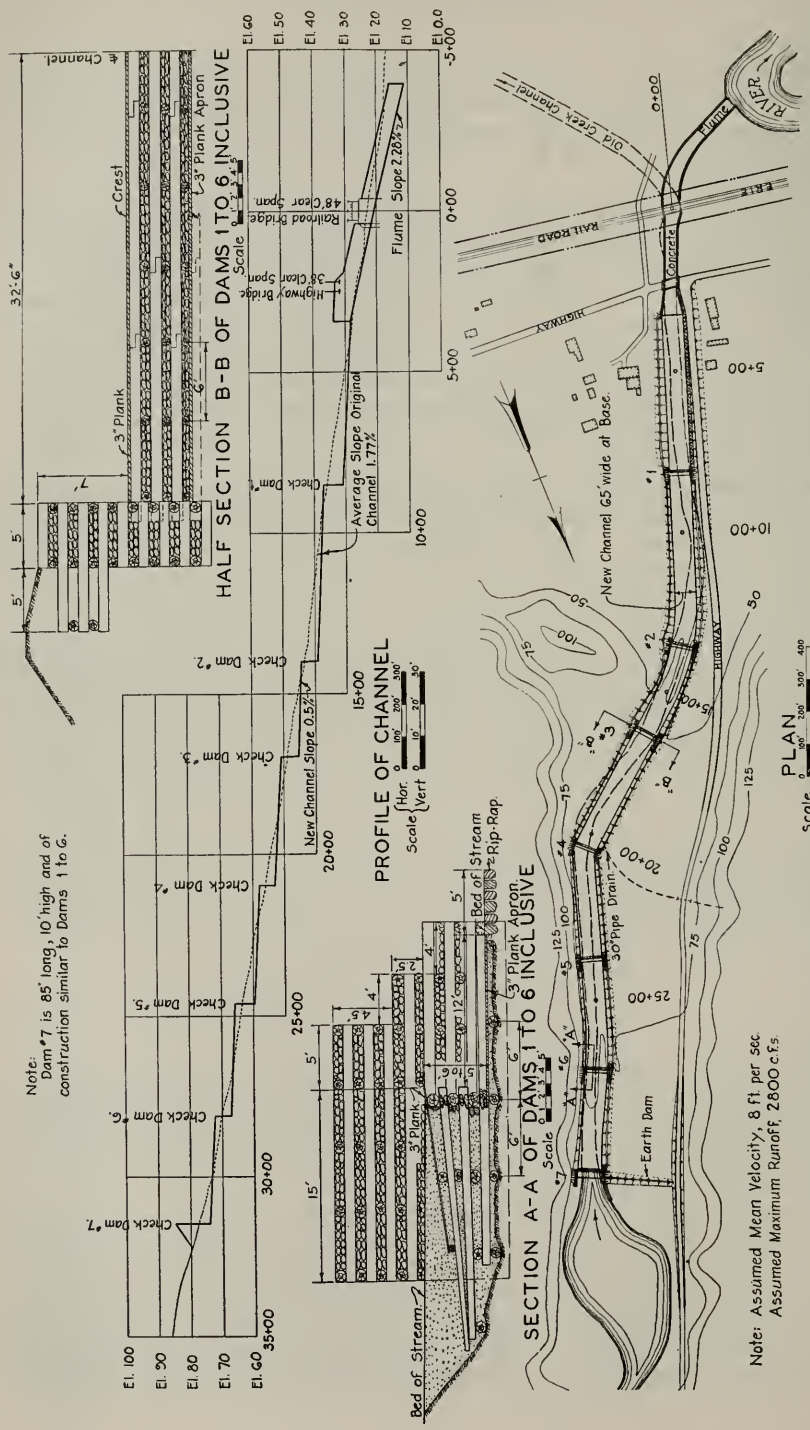


Fig. 1.—Check Dam Installation Made by Erie Railroad at Canisteo, N. Y., and Used in U. S. Army Engineers Report as Recommended Typical Plan.

the old channel bed in order to create a pool or settling basin above. This was done in order to stop the transportation of material from above which might be carried into the controlled section in the event of a flood discharge greater than the designed maximum of 2,800 cfs. When the basin becomes filled, the floor of the channel is raised for some distance above the check dam; the slope and stream velocity are thereby reduced and added control results.

The correct locations for the check dams can best be determined by starting at a control point. In Fig. 1 this is at the upper end of the concrete flume but in most cases the control point will be at the railway bridge. From that point the proposed grade line, superimposed upon the profile of the existing channel bed, will indicate approximately the points where the check dams should be constructed so as to reduce necessary lateral movement of the excavated material to a minimum. The trial locations can be shifted for greater economy of design when the channel cross-sections are studied. It may be found desirable to alter somewhat the channel alinement, although no attempt should be made to provide a straight channel. It is possible, however, that some sharp bends should be eased.

Another point to consider in selecting the best locations for the check dams is that of stabilized flow. The reaches between the check dams, where the discharge is between 1,000 and 3,000 cfs, should be at least 200 ft. long and preferably longer. It is important, in theory at least, that all turbulence caused by the water falling at one check dam be eliminated before reaching the next. This may in some degree control the height of the check dams as it may be necessary to increase the height in order to secure sufficient distance between them.

If the check dam treatment of a stream is to be practical, the physical conditions must be such that the necessary length of treated section falls within economic limits and terminates at a point where a minimum of transported material will be carried from above into the improved section. There will be no particular advantage and may be added expense if the point from which transported material must be removed is changed from the immediate vicinity of the railway structure to one considerably upstream. One of three natural conditions may be found which will afford a suitable upper limit of the improvement. These are (1) where the natural stream profile flattens so that the slope produces a non-erosive velocity; (2) where the flood plane widens, causing a drop in velocity and a deposit of materials brought from above and; (3) where the channel emerges from a type of material which is not eroded by the uncontrolled stream velocity. It may be found that the improved channel section need not be continuous but can be installed in separate sections from which material is being carried. It may also be necessary to control by the same, or some other method, small feeder streams which enter the main stream within the limits of the controlled section.

At the upper limit of the controlled section provision may be required which will assure the flow of all the water over the upper check dam and into the enlarged channel between the levees. Where the improvement terminates in a narrow gorge, no such provision will be necessary but where this is not the case it may be necessary to construct low dams of some type extending from the anchor crib of one or both ends of the upper check dam to points beyond the limits of the flood plane. Such a barrier, if conditions are favorable, may be so constructed as to serve as a fuse plug which would be over-topped by a discharge greater than the capacity of the improved channel and thereby prevent damage to the levees and check dams.

CHANNEL AND LEVEES

Usually the natural channel throughout the section to be treated will be cut in material which has been deposited during the receding of past flood stages. With the velocity of flow controlled, this material is suitable for use in the channel sides or levees. It is probably advisable to slope the sides 1¾ to 1, although slopes of 1½ to 1 have stood for several years with very little movement. What movement has occurred is due to the washing out of the finer materials which are transported even at the controlled velocity. This causes some settlement at first but with no appreciable change in channel section.

The top of the levees should have a minimum width of three feet and be at least two feet above assumed maximum high water elevation. Borrow for levee construction and waste from channel excavation can be reduced to a minimum by the proper adjustment of the proposed grade line and alinement with relation to the natural grade and line. As already stated, a satisfactory balance can be obtained by shifting somewhat the locations of the check dams.

In small streams where the levees are within the working range and where low stream flow permits, the channel work can best be performed by a shovel working within the channel. On larger streams, dragline outfits will be necessary, working from one or both sides. The side slopes and channel bed should be hand-dressed to uniform line and grade so as to insure smooth hydraulic action.

Riprap paving should be installed across the channel bed from the edge of the check dam aprons for a width of four to six feet and the side slopes should be similarly protected at both the upper and lower ends of the anchor cribs.

Surface drainage from outside the levees, if necessary, can be conducted to the channel by the installation of pipes through the levees. Probably the most suitable material for this purpose is paved, corrugated metal, due to almost certain settlement of the levee and possible damage by floating debris at the channel end. In most cases such pipes would be above the maximum high water elevation in the channel. If this is not the case at the natural point of entrance, the water can be conducted to a point where entrance to the channel can be made just below a check dam where the water surface drops. Such an installation was made at Sta. 20 + 00 in Fig. 1.

Mention has been made above to the possible need of high velocity flows through sections of the improvement, due to restrictive waterway openings. Openings which have been adequate under natural stream velocity may not afford sufficient opening under the reduced velocity. This might be the case at the railroad bridge. If so, the bridge span must be increased or some type of high velocity drop structure, or a conduit operating under head must be installed. Structures for this purpose, which vary widely in detail of design, do not fall within the scope of this subject. In the installation shown in Fig. 1 it was found cheaper to install a high velocity flume, through both highway and railway bridges, than it would be to replace the bridges with others having adequate capacity at low velocity.

This method of stream control has no effect upon the quantity of discharge as the same amount of water will pass through the railway opening in a given time as was passed before the improvement was made, therefore no consideration need be given to channel or other conditions below the railway except that the channel should be of sufficient capacity for a sufficient distance so that no back water effect will result at the railway opening.

CHECK DAMS

The term "Check Dam" is somewhat misleading. It probably originated with installations where structures were built which extended across and above the channel floor in order to check the movement of channel materials. This is not the case in the method described in this report where they serve only as vertical steps in the channel floor but the term has been borrowed for want of a better one. "Check" here means a check of velocity and not a check of channel materials or quantity of water.

So long as the purpose of the check dam is obtained, and stability assured, the design and choice of materials, in most cases, can be determined by the economic factor. Those illustrated in Fig. 1 are open-faced cribs, constructed of oak poles, obtained locally, and with oak plank decks and aprons. All intersections of crib members are fastened with ¾ inch genuine, wrought iron drift pins. The planks are held in place with boat spikes. This particular design has proved very stable. The check dams were designed to pass the 2,800 cfs with a 5-ft. head but in 1935 when the drainage area received over 7 in. of rain during one storm the water was over the tops of the anchor cribs and it was estimated that over 6,000 cfs was passed, without damage to the structures. This storm, however, demonstrated the need of riprap protection of the slopes at both the upper and lower ends of the anchor cribs.

Another design of timber construction is illustrated in Fig. 2. This design was developed for the treatment of smaller streams where the maximum runoff is assumed at from 400 to 1,000 cfs. The design permitted the use of second hand, treated timber released from bridge decks. It has been used in check dams up to nine feet high although experience indicates that a height of about six feet is the most economical. The apron in this design is constructed below the grade line and a sill is placed across the downstream end. This creates a pool which serves as a cushion for the falling water and reduces turbulence where it enters the earth channel. The anchor cribs have closed faces and ends because at the points they were installed large stones were not available in sufficient quantities to chink the open spaces and prevent washing out of the finer backfill materials.

If more permanent construction is desired, concrete can be used, either plain or reinforced. Concrete check dams should have the aprons protected with plank, or an adequate water cushion should be provided in the design.

Some commercially manufactured concrete crib members also afford easy adaptation for both the spillway and anchor cribs. With such construction, reinforced slab or timber plank aprons should be provided.

Where sufficient penetration to insure stability can be secured, low check dams could be formed by driving sheet piling across the channel. The height could be increased somewhat by suitable anchorage.

COST

The total cost of the work shown in Fig. 1, which was carried out under contract in 1930, was $80,000. This figure includes the cost of the concrete flume and changes in the highway, and rather expensive easement cost, none of which would be necessary on most projects. Engineering charges were also much higher than on any of the several similar jobs which followed. The actual cost of the channel and levee work, the construction of the check dams and the riprap was $35,000. On several other streams where 400 to 1,000 cfs runoff was used as a basis for design and where the check dams were constructed of second hand timber, charged out at $10 per M ft. b. m. (see Fig. 2), the

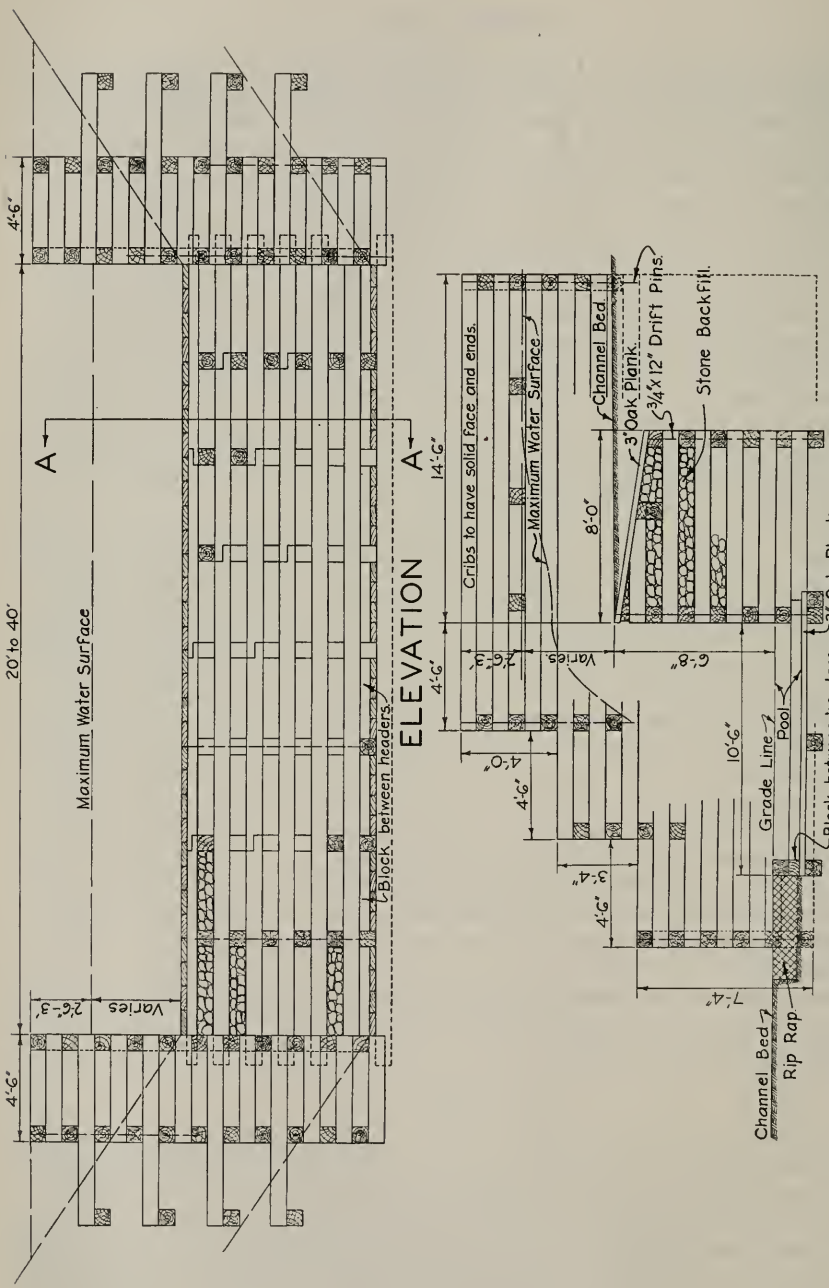


Fig. 2.—Typical Design for Timber Check Dams.

cost was from $12,000 to $20,000. One such job with 800 cfs runoff required nineteen 28 ft. check dams in the 2,000 ft. of channel controlled. The total cost was $18,000.

In a few cases it has been possible to secure substantial contributions from the county, state or some other agency where a highway also suffered damage from the streams.

CONCLUSIONS

Where annual maintenance costs justify the expenditure and where the conditions fall within the limits described in the foregoing, this method of stream control is recommended.

Report on Assignment 3 (a)

Pipe Line Crossings—Specifications for Non-Inflammable Substances under Pressure

W. C. Swartout (chairman, subcommittee), F. W. Capp, J. A. Given, Paul McKay, C. S. Robinson, L. H. Roden, E. M. Smith.

Last year your committee presented as information Specifications for Pipe Line Crossings for Non-Inflammable Substances under Pressure and invited suggestions and criticisms from the members. As no criticisms or suggestions have been received, the committee offers these specifications, without change from the form in which they appear in the Proceedings for 1941, Vol. 42, pages 557–558, for approval and publication in the Manual.

Report on Assignment 3 (c)

Specifications for Perforated Pipe for Subdrainage

W. C. Swartout (chairman, subcommittee), F. W. Capp. J. A. Given, Paul McKay, C. S. Robinson, L. H. Roden, E. M. Smith.

The following Specifications for Corrugated Metal Culverts are offered by your committee as information. Your comments and criticisms are invited.

They cover a material used extensively and successfully in curing water pockets in the roadbed, particularly under tracks carrying fast heavy traffic.

Few conditions are encountered which absorb more of the money appropriated by the railroads for line and surface with less to show for it after it is spent than aggravated cases of water pockets. Of the several methods employed for curing this condition, subdrainage is used as often if not more often than any others.

The committee requests the continuation of this assignment with the object of submitting the specifications for adoption and publication in the Manual in 1943.

III CULVERTS

305. CORRUGATED METAL CULVERTS

SPECIFICATIONS FOR CORRUGATED METAL UNDERDRAIN PIPE

1. Scope

These specifications cover corrugated metal pipe for use as underdrains. Unless otherwise specified, the pipe shall be perforated.

2. General Requirements

Except as herein modified, the pipe shall comply with the applicable sections of the AREA Specifications for Corrugated Metal Culverts, (Manual, page 1–13) except that when 6-inch and 8-inch pipe is specified, the pipe may be either riveted pipe conforming to the specifications referred to or it may be pipe having helical corrugations which are continuous from end to end of each length of pipe, with a continuous lock seam paralleling the corrugations, or an approved type of continuous welded longitudinal seam. The seam shall be so constructed as not to affect the shape or nominal diameter of the pipe, nor shall it reduce the strength of the pipe.

3. Corrugations

If pipe with helical corrugations is supplied, the corrugations shall be true circular arcs connected by tangents. They shall be not less than 1⅜ inches nor more than 1¾ inches center to center of crests, measured at right angles to the direction of the corrugations; and the depth of corrugations shall be not less than ¼ inch.

4. Perforations

The perforations shall be approximately ⅜ inch in diameter as measured on the finished pipe and shall be located in the inside crests of the corrugations. Perforations shall be in straight rows extending to within 4 inches of each end of each length of pipe. Unless otherwise specified, perforations shall be made after the pipe is galvanized; and they shall be in two groups with half the number of rows of perforations on either side of an unperforated bottom segment. The number of rows of perforations and the width of the unperforated segment shall be as shown in the table below. Within each of the two groups of perforations, the rows shall be spaced on approximately 1-inch centers, measured circumferentially.

Nominal Internal Dia. Inches	*Total No. Rows of Perforations*	*Approximate Width of Unperforated Segment-Inches*	*Computed Weight per Linear Foot of Pipe, in Pounds Galvanized Sheet Gage Number*				
			16	*14*	*12*	*10*	*8*
6	6	3½	4.7*				
8	6	5½	7.3*				
10	6	8¾	9.0*				
12	6	11¾	10.5*	13.1			
15	8	13½	12.9	16.1*			
18	8	18½	15.3	19.1*	26.4		
21	10	20	17.7	22.1*	30.6		
24	10	23	20.4	25.2	34.7*	44.2	
30	12	29½		30.9	43.0*	54.8	
36	12	39		37.1	51.0	65.4*	79.4
42	16	42		43.6	59.5	76.8*	93.2
48	16	54			68.0	87.4*	106.1*

* Gages marked with an asterisk are those ordinarily used under track, but gage of pipe shall be as specified on the plans or in the bid invitation.

Report on Assignment 3 (d)

Specifications for Multiplate or Sectional Plate Pipe and Arches

W. S. Swartout (chairman, subcommittee), F. W. Capp, J. A. Given, Paul McKay, C. S. Robinson, L. H. Roden, E. M. Smith.

The following Specifications for Multiplate or Sectional Plate Pipe and Arches are offered by your committee as information for the purpose of soliciting comments and criticisms before recommending them for approval and publication in the Manual.

There is a definite need for these specifications because literally thousands of structures on the railroads have been constructed of plates ranging from 7 gage to 1 gage with 6-in. corrugations since the material was introduced in 1931 without the benefit of any specifications except the applicable paragraphs in specifications for corrugated culverts.

The material is used almost exclusively by the railroads and the builders of highways. Therefore, with the object of obviating the confusion that would result from conflicting requirements of two specifications, your committee has elected to adopt the specifications of the American Association of State Highway Officials as of January 1, 1941, insofar as they are applicable to railroad practice and requirements.

It will be observed that the specifications are divided, for convenience, into four parts:

(1)—Material, (2)—fabrication, (3)—design and (4)—construction.

III CULVERTS

305. CORRUGATED METAL CULVERTS

SPECIFICATIONS FOR MULTIPLATE OR SECTIONAL PLATE PIPE AND ARCHES

Adapted from Specifications of the American Association of State Highway Officials, Third Edition

I MATERIAL

101. Scope

These specifications include material used in field fabrication of culvert structures which are too large for transportation as finished structures, due to obvious shipping limitations, or are too heavy for economical or convenient handling in the field. This makes available structures having the advantages of the flexible type structure capable of carrying heavier loads and of larger diameters than is possible with structures fabricated from sheets of lighter gages due to the practical limitations in gage of metal for standard 2¾-inches corrugations.

102. Description of Plates

Plates shall consist of structural units of galvanized corrugated metal. The corrugations shall have a pitch of 6 inches with a tolerance of ¼ inch and a depth of 1½ inches with a tolerance of ⅛ inch, plus or minus. Standard plates shall have a covering width of not less than 47 inches, measured along the neutral axis of the plate and shall be

available in nominal lengths of 10 feet, 7½ feet, 5 feet and 2½ feet. (Plates have approximately a 2-inch lip beyond each end crest, which results in the actual length of a given structure being approximately 4 inches longer than the nominal length, except when skewed or beveled. In constructing footings for arches, this additional length must be provided for.

The gage of plates and radii of curvature shall be as shown on the plans.

The plates at longitudinal and circumferential seams shall be connected by bolts. Circumferential seams shall be staggered, so that no circumferential seam shall be continuous for a greater distance than the width of the plates.

103. Base Metal

The base metal of the corrugated plates shall conform to the requirements of Table 101 of the AREA Specifications for Corrugated Metal Culverts (see Manual, page 1–13) for the particular class of metal designated in the bid invitation.

104. Spelter Coating

A coating of prime western spelter or equal shall be applied by the hot-dip process at the rate given below per square foot of double-exposed surface.

Pipe 60 to 120 inches in diameter (inclusive) and arches:

No. 8 to No. 10 gage, incl., 2 ounces
No. 1 to No. 7 gage, incl., 3 ounces

Pipe 135 to 180 inches in diameter (inclusive) 3 ounces

If the average spelter coating as determined from the required samples is less than the amount specified above, or if any one specimen shows a deficiency of 0.2 ounces where a 2-ounce coating is specified, or a deficiency of 0.3 ounce in the case of a 3-ounce coating requirement, the lot sampled shall be rejected. Spelter coating shall be of first-class commercial quality, free from injurious defects, such as blisters, flux and uncoated spots.

All pipe and arches for which 3-ounce spelter is required shall be galvanized after fabrication. When gages No. 8 and lighter are used, the metal may be galvanized either before or after fabrication.

105. Sampling

For testing the weight of the spelter coating and for chemical analysis of the base metal, when required, a sample approximately 3 inches square, or a sample of equivalent area, shall be cut from the corner of one plate in each 100 plates of a shipment or fraction thereof.

106. Chemical Analysis and Tests for Spelter Coating

When required, the chemical analyses of base metal shall be made in accordance with current ASTM Specification E 30.

The test for weight of spelter coating shall be made in accordance with the hydrochloric acid-antimony chloride method as described in current ASTM Standard Method A 90.

107. Identification

No plates shall be accepted unless the metal is identified by a stamp on each plate showing:

1. Name of base metal manufacturer
2. Name of brand and kind of base metal
3. Gage number
4. Weight of spelter coating
5. Identification symbols showing { heat number / pot number }

The identification brands shall be so placed that when the pipe or arch is erected, the identification will appear on the inside of the structure.

108. Bolts

Bolts for connecting plates shall be not less than $\frac{11}{16}$ inch in diameter, and shall be hot-dip galvanized. The threads shall be American National Coarse Thread Series, Class 2 fit.

They shall meet the following physical test requirements:

Minimum tensile strength	110,000 lb. per sq. in.
Minimum shear	80,000 lb. per sq. in.
Minimum reduction of area	35 percent
Brinell hardness between the limits	241–286

The tests shall be made on finished bolts. Unless otherwise authorized, the bolts shall be furnished so they may be sampled and tested before erection is commenced.

Bolt heads and nuts shall be of special design to provide even and uniform bearing on the curved corrugated surfaces or special washers shall be used in lieu thereof.

109. Gage Determination and Tolerance

Where mill or factory inspection is employed, the gage shall be determined by the weight of flat plates before corrugating. The average weight of any one lot of plates shall not underrun the theoretical weight by more than 5 percent and no individual plate shall underrun the theoretical weight by more than 10 percent.

110. Field Inspection and Acceptance of Plates

The field inspection shall be made by the Engineer, who shall be furnished with an itemized statement of the number and length of the plates in each shipment by the manufacturer.

Each plate included in a shipment shall fully meet the requirements of these specifications; and if 25 percent of the plates in any shipment fail to meet the requirements the entire shipment may be rejected.

II FABRICATION

201. Forming and Punching Plates

Each plate shall be curved to the proper radius, and the bolt holes shall be so punched that all except end plates shall be interchangeable in the erection process. As an alternate to this punching, the plates used in the two bottom segments of the arch shall be punched with one row of bolt holes adjacent to the longitudinal edge of the plate which is to rest upon the pier or abutment.

Unless otherwise specified, bolt holes along those edges of the plates that will form longitudinal seams in the finished structure shall be staggered in rows 2 inches apart, with one row in the valley and one in the crest of the corrugations.

Bolt holes along those edges of the plates that will form circumferential seams in the finished structure shall provide for a bolt spacing of approximately 12 inches.

The center of no hole shall be closer to the edge of the plate than 1¾ times the diameter of the bolt. The diameter of the bolt hole shall not exceed the diameter of bolts by more than $\frac{3}{32}$ inches.

Bolt holes in plates of No. 1 to No. 7 gage, inclusive, shall be punched before the plates are galvanized.

When the completed structure is to be a full circle pipe, the plates shall be so curved that when bolted together, true circles shall be formed of the required diameter. The diameter of the pipe, in inches, divided by 15, shall determine the number of plates required to make a full circle, unless otherwise shown on the plans. When the completed structure is to be an elliptically shaped pipe, the plates shall be curved to the radii shown on the plans.

Plates for forming skewed or sloped ends shall be cut so as to give the angle of skew or slope specified. Burnt edges shall be free from oxide or burrs, shall present a workmanlike finish and legible identification numerals shall be placed on each part plate to designate its proper position in the finished structure.

III DESIGN

301. Gage of Side and Top Plates for Pipe Structures

PIPE UNDER TRACK—E-72 LOADING

Diam. of Pipe Inches	*Height of Cover Above Top of Pipe, Ft.* 3–10	11–20	21–30	31–40	41–50	51–60	61–80
60	8	8	8	8	7	5	3
75	7	8	8	7	5	3	
90	5	7	7	5	3		
105	5	5	5	3	1		
120	3	5	3	1			
135	1	3	1				
150	1	1	1				
165		1					
180		1					

Note: Unless otherwise indicated on the plans or in the gage table, all pipe shall be elongated vertically 3 percent before placement of fill, in accordance with Article 404 of these specifications.

PIPE NOT UNDER TRACK—H-20 HIGHWAY LOADING

Diam. of Pipe Inches	*Height of Cover Above top of Pipe, Ft.* 2–5	6–10	11–15	16–20	21–25	26–30	31–40	41–50	51–60	61–80
60	10*	10*	10*	10 or 8*	10 or 8*	10 or 7*	10 or 5*	8 or 3*	7 or 3*	3 or 1*
75	10*	10*	10 or 8*	10 or 7*	10 or 5*	8 or 5*	8 or 3*	7 or 1*	5	3
90	10	10 or 8*	10 or 7*	8 or 5*	8 or 3*	8 or 1*	7	5	3	
105	10	8	8 or 5*	7 or 3*	7 or 1*	5	5	3		
120	10	8 or 5*	7 or 3*	5 or 1*	5	5	3	1		
135	8	7 or 3*	5 or 1*	5	3	3	1			
150	8	5	5	3	3	1	1			
165	7	5	3	3	1	1				
180	7	5	3	3	1	1				

* Gages shown with (*) need not be strutted.

302. Minimum and Maximum Heights of Cover for Pipes

For pipe structures under track, the height of cover measured from base of rail to top of pipe shall be not less than half the diameter of the pipe. For pipe not under track, the height of cover shall be not less than 2 feet for pipe diameters 60 inches and larger.

The height of cover for strutted pipe may be increased 50 percent provided that the number of bolts used per foot of longitudinal seam is increased from 4 to 6, and provided the gage used is No. 1.

303. Gage of Bottom Plates for Pipes

For pipes having a lighter gage than No. 1, the bottom plates shall have the next heavier gage shown in the gage table, unless otherwise provided by supplemental specifications or by notes on the plans. The additional metal is provided to resist abrasion.

304. Gage of Plates for Arches

Arch structures, depending upon whether the arch is to be used to strengthen an existing structure or to carry the full load, shall be individually designed. Where these specifications are used for arches, the gage of plates shall be as shown on the plans.

305. Number of Bolts

Not less than four bolts shall be used per foot of longitudinal seam for either pipe or arches. If a pipe is to be placed under greater height of cover than given in the tables, the bolts shall be increased in number as specified in Article 302. Where ends are skewed $\frac{11}{16}$ inch, hook belts at 12-inch centers shall be used to anchor the plates to the headwalls.

IV CONSTRUCTION

401. Multiple Pipes

Where multiple lines of pipe are installed, the adjacent sides shall be one-half diameter apart up to 4 feet to permit careful tamping of the filling material.

402. Bedding and Backfilling—Pipe Structures

When a pipe structure is to be erected in a trench, the width of the trench must be sufficient to permit thorough tamping of the earth backfill against every plate except the bottom one.

The pipe shall be bedded in an earth foundation of uniform density carefully shaped, by means of a template supported at the desired grade, to fit the lower plate of the pipe. Where rock in either ledge or boulder formation is encountered, it shall be removed below grade and replaced with suitable materials in such manner as to provide a compacted earth cushion having a thickness under the pipe of not less than ½ inch per foot height of fill over the top of the pipe, with a minimum allowable thickness of 8 inches. Where a firm foundation is not encountered, at the grade established, due to soft, spongy or other unstable soil, unless other special construction methods are called for on the plans or in special provisions, all of such unstable soil, under the pipe and for a width of at least one diameter on each side of the pipe, shall be removed and replaced with gravel or other suitable material properly compacted to provide adequate support for the pipe line.

Selected material, preferably of a gravelly nature, free from all material which will not pass a 3-inch circular ring shall be used in the backfilling operations. The 3-inch size limitation shall not apply to fill over one diameter above the pipe. Backfilling material

shall also be free from vegetable matter, frozen lumps, cinders, and all other objectionable substances. Allowance of a minimum camber of 1 percent of the length of the pipe shall be made to take care of settlement after placing the fill. The amount of camber shall be varied to suit the height of fill and supporting soil.

After the pipe has been assembled, fill material shall be deposited evenly on both sides of the pipe, in not to exceed 6-inch layers, until at least the ¾ point has been reached. Special care shall be taken to thoroughly tamp the backfilling material between the pipe and the sides of the trench or for a distance each side of the pipe equal to the diameter of the pipe. Above the ¾ point, the fill shall be placed uniformly on each side of the pipe in layers not to exceed 12 inches until a height is reached equal to the diameter of the pipe, after which the remainder of the fill may be made from one direction, but only under the supervision of the Engineer.

403. Backfilling Arch Structures Under New Fills

When backfilling arches before headwalls are placed, the first material shall be placed midway between the ends of the arch forming as narrow a ramp as possible until the top of the arch is reached. The ramp shall be built evenly from both sides, and the backfilling material shall be thoroughly compacted as it is placed. After the two ramps shall have been built to the top of the arch, the remainder of the backfill shall be deposited from the top of the arch both ways from the center to the ends, and as evenly as possible on both sides of the arch.

If the headwalls are built before the arch is backfilled, the filling material shall first be placed adjacent to one headwall, until the top of the arch is reached, after which the fill shall be dumped from the top of the arch toward the other headwall, with care being taken to deposit the material evenly on both sides of the arch.

In multiple installations the procedure above specified shall be followed, but extreme care shall be used to bring the backfill up evenly on each side of each arch so that unequal pressure will be avoided.

In all cases the filling material shall be thoroughly but not excessively tamped. Puddling the backfill will not be permitted.

404. Assembly and Strutting Instructions

The plate manufacturer shall supply with each structure detailed instructions for assembling and strutting. If the ends of the pipe are skewed or beveled, a diagram shall be supplied showing layout of plates and their position in the finished structure.

Strutting shall be carried uniformly from end to end of the pipe for pipes without headwalls. When headwalls are used there shall be no elongation of the ends of the pipe. The struts shall be left in place until the fill is completed and compacted, unless otherwise instructed by the Engineer.

Where timber strutting is employed, the pipe shall be elongated the required amount by means of suitable jacks. The method of strutting shall meet with the approval of the Engineer. A tolerance of ¼ percent above and below the specified percent of elongation will be permitted.

Report on Assignment 3 (e)

Vitrified Clay Pipe Culverts—Specifications

W. C. Swartout (chairman, subcommittee), F. W. Capp, J. A. Given, Paul McKay, C. S. Robinson, L. H. Roden, E. M. Smith.

Last year your committee presented Specifications for Vitrified Clay Culvert Pipe, known to the industry as Extra Strong or Triple Strength, with the expectation that they would be recommended for adoption and inclusion in the Manual. However, certain additional data received just prior to the convention pointed to the advisability of withholding such action to afford time for a further study of the proposed specifications. As a result, the draft now presented not only has the approval of the Clay Products Association, and conforms with ASTM Specifications D 13–40 for Clay Sewer Pipe so far as they are applicable, but also is believed to be in harmony with current drafts of the specifications being prepared by the Federal Specifications Committee.

These specifications are therefore being submitted with the recommendation that they be adopted and published in the Manual.

III CULVERTS

302. VITRIFIED CLAY PIPE CULVERTS

A. SPECIFICATIONS FOR EXTRA STRONG OR TRIPLE-STRENGTH VITRIFIED CLAY CULVERT PIPE

Adapted from ASTM Specification C 13–40

GENERAL

1. Scope

These specifications cover vitrified clay pipe intended to be used for the construction of culverts and other projects where conditions require that extra strength pipe be used.

2. General

(a) Pipe furnished shall be of one grade of clay pipe of bell and spigot pattern unless otherwise specified.

(b) Pipe shall be salt glazed unless otherwise specified.

3. Materials

(a) Clay pipe shall be manufactured from surface clay, fire clay, or shale or a combination of these materials.

(b) These materials or any combination thereof, when molded into pipe and subjected to suitable temperatures, shall produce a product that will be strong, durable, serviceable, free from objectionable defects and shall conform to these specifications.

RESISTANCE TO ACTION OF ACIDS

4. Resistance to Action of Acids

The following tests as to resistance to the action of acids may be prescribed.

5. Reagent

When testing with either hydrochloric, nitric, sulfuric or acetic acid, as specified by the Purchaser, using 1 *N* acid,[1] the percentage of acid-soluble matter shall not exceed 0.25 percent. The purpose of this test is to determine the resistance of pipe to the action of acids and its use is optional.

6. Test Specimens

Specimens shall be sound with all edges freshly broken, free from cracks or shattered edges, about 2 by 2 inches in face area and equal in thickness to the thickness of the barrel of the pipe, not weighing more than 200 g. and shall be thoroughly cleaned with a wire brush.

7. Number of Tests

A test shall be made on at least one specimen cut from each size of pipe. The results shall be reported separately for each individual specimen.

8. Weighing Apparatus

The weighing of the specimen shall be made on a balance accurate to 0.01 g. when loaded with 200 g.

9. Test Procedure

(a) Specimens to be tested shall be dried to constant weight at a temperature between 210 degrees and 230 degrees F.

(b) The specimens upon reaching constant weight shall be suspended and completely immersed in the test solution at a temperature between 70 degrees and 90 degrees F. for a period of 48 hours, then removed from the solution, carefully and thoroughly washed with hot water, allowing the washings to run into the solution in which the specimen was immersed. This solution shall be filtered and the filter washed with hot water, adding the washings to the filtrate. To the filtrate and washings there shall be added 5 ml. of sulfuric acid (sp. gr. 1.83). This solution shall then be evaporated (avoiding loss of spattering) to about 5 ml.; transferred to a porcelain crucible (previously ignited to constant weight) and heated cautiously to dryness. It shall then be ignited to constant weight.

10. Calculation

The percentage of acid-soluble matter shall be calculated as follows:

$$\text{Percentage acid-soluble matter} = \frac{\text{Wt. of residue in grams} \times 100}{\text{Wt. of dry specimen in grams}}$$

If the acid-soluble matter exceeds 0.25 percent, it shall be considered that the pipe fails to conform to the requirement for resistance to the action of chemicals.

PHYSICAL PROPERTIES AND TESTS

11. Physical Requirements

Strength shall conform to the requirements given in Table 1. The individual results of the various tests for each size of pipe and for each shipment shall be tabulated separately so as to show the percentage which fails to conform to the requirements of each test.

[1] These 1 *N* solutions should contain, respectively, 36.5, 63, 49 and 60 grams of the acid per liter, of solution. For the purpose of these tests the solutions can be prepared by taking the following volumes of acid and diluting to 1 liter: sulfuric acid, specific gravity 1.83, 28.5 ml; hydrochloric acid, specific gravity 1.18, 88.9 ml; nitric acid, specific gravity 1.41, 65 ml; and glacial acetic acid, specific gravity 1.05, 57.7 ml.

TABLE 1. DIMENSIONS AND REQUIRED STRENGTH OF VITRIFIED CLAY CULVERT PIPE

Size (In.)	Required Strength Pounds per Lin. Foot 3 Edge Bearing	Sand Bearing	Laying Length (Feet)	Outside Diameter of barrel (inches) Min.	Max.	Inside Diameter of socket at ½ inch above base (inches) Min.	Max.	Depth of Socket (inches) Depth	Permissible Minimum
6	2250	3150	2, 2½, 3	7 1/16	7 7/16	8 3/16	8 11/16	2¼	2
8	2250	3150	3	9¼	9¾	10½	11⅛	2½	2¼
10	2250	3150	3	11½	12	12¾	13⅜	2½	2¼
12	2250	3150	3	13 11/16	14 5/16	15 1/16	15 13/16	2¾	2½
15	2750	3930	3, 4	17 3/16	17 13/16	18 9/16	19 5/16	2¾	2½
18	3300	4720	3, 4	20 9/16	21 7/16	22 3/16	23 13/16	3	2¾
21	3850	5500	3, 4	24	25	25¾	26⅞	3¼	3
24	4400	6280	3, 4	27 7/16	28 9/16	29 5/16	30 9/16	3⅜	3⅛
30	5000	7850	3, 4	34⅜	35⅝	36⅜	37¾	3½	3¼
36	6000	9430	3, 4	40¾	42¼	43	44⅝	4	3¾

TABLE 1. DIMENSIONS AND REQUIRED STRENGTH OF VITRIFIED CLAY CULVERT PIPE—Continued

Size (Inches)	Thickness of Socket (inches) Inches	Permissible Minimum	Thickness of Barrel Inches	Permissible Minimum	Permissible Under run per Foot of Length (inches)	Permissible Difference in Length of Two Opposite Sides (in) Per Foot of Length
6	15/32	7/16	1	⅞	¼	⅛
8	9/16	½	1⅛	1	¼	⅛
10	21/32	⅝	1¼	1⅛	¼	⅛
12	¾	11/16	1¼	1⅛	¼	3/16
15	15/16	27/32	1⅝	1½	¼	3/16
18	1⅛	31/32	1⅞	1¾	¼	3/16
21	1 5/16	1 1/16	2¼	1 1/16	¼	3/16
24	1½	1⅜	2½	2 5/16	⅜	¼
30	1⅞	1¾	3	2¾	⅜	¼
36	2 1/16	1⅞	3½	3¼	⅜	¼

Note: Minimum Taper of Socket: 1:20. Thickness of socket shall be measured ½ in. from outer end. The minus sign (—) indicates that the plus variation is not limited.

12. Test Specimens

The specimens for purpose of tests shall be sound, full-size pipe and shall be selected by the Purchaser or his representative at the point or points designated by him when placing the order. Specimens having cracks or other defects in form or dimension in excess of the specified limits, as given in Table 1, shall be discarded and replaced with other pipe from the shipment.

13. Number of Tests

The manufacturer or seller shall furnish specimens for test, without charge, up to 0.5 percent of the number of pipes in each size of pipe furnished, except that in no case shall less than two specimens be furnished.

14. Measurement and Observation of Specimens

The specimens shall first be freed from all visible moisture. When dry, each specimen shall be measured and inspected. The results of these observations shall be recorded.

STRENGTH TESTS

15. Strength Tests

Pipe shall be tested for strength by either the three-edge-bearing method or the sand-bearing method as described in Sections 18 and 19. Either of the two specified bearing methods shall be used on re-tests as provided for in Section 25 (a) and (b). At least 75 percent of the specimens received for testing shall be subjected to the strength test.

When pipe is furnished longer than the maximum length set out in Table 1, specimens furnished for test purposes shall not be required in longer lengths than 4 feet.

16. Application of Load

(a) In making the test any prime mover or hand power which will apply the load at a uniform rate of about 2,000 pounds per minute or in increments of not more than 100 pounds at the same rate, may be used in making the test.

(b) The center of the load shall be applied to the top bearing block at a point distant from the spigot end of the pipe equal to one-half of the over-all length of the pipe. The test load shall be applied to the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings. In testing pipe that is "out of straight," the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair test.

(c) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(d) The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part. The bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum loads produced by the tests without lost motion, vibration, or sudden shock.

(e) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

(f) The applied load shall equal the requirements of this specification as given in Table 1.

17. Three-Edge-Bearing Method

When the three-edge-bearing method (See Fig. 1) is used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test. The lower bearings shall consist of two wooden strips with vertical sides having their interior top corners rounded to a radius of approximately ½ inch. The strips shall be straight and securely fastened to a rigid block at least 6 by 6 inch in cross-section. The interior vertical sides of the strips shall be parallel and a distance apart of 1 inch per foot of pipe diameter but in no case less than 1 inch. Before the pipe is placed, a fillet of plaster of Paris or other equalizing material, such as sand and sulfur, thick enough to compensate for the inequalities of the pipe barrel shall be cast on and between the lower bearings. The pipe shall be placed on the fillet while the plaster of Paris is still somewhat plastic. The use of the plaster of Paris fillet may be dispensed with when mutually agreeable to the manufacturer and the Purchaser. The upper bearing shall be a rigid wooden block at least 6 by 6 inch in cross-section, straight and true from end to end. A fillet of plaster

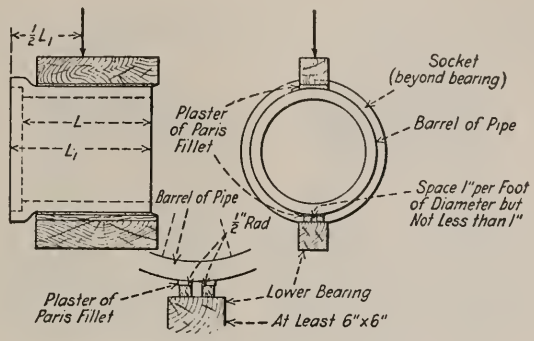


Fig. 1.—Three-Edge Bearings.

of Paris thick enough to compensate for the inequalities of the pipe barrel shall be cast along the top of the pipe to provide a uniform support for the upper bearing block. The upper bearing shall be brought in contact while the plaster of Paris is still somewhat plastic. The upper and lower bearings shall extend the full length of the pipe exclusive of socket.

When testing pipe 24 inches in diameter and larger, or more than 3 feet in length, the load shall be distributed to the top of the upper bearing through a steel beam or other stiff member to minimize the deflection of the block.

18. Sand-Bearing Method

(a) When the sand-bearing method (see Fig. 2) is used, the ends of each specimen of pipe shall be accurately marked in quarters of the circumference prior to the test. Specimens shall be carefully bedded in sand, above and below, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.

(b) The sand used shall be clean and moist, and shall be such as will pass a 4,760-micron (No. 4) sieve.[2] The sand in the lower bearing shall be loose when the pipe is placed.

(c) The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck off level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate in such manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used.

(d) The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

[2] For requirements for this sieve, see Standard Specifications for Sieves for Testing Purposes (ASTM Designation E 11).

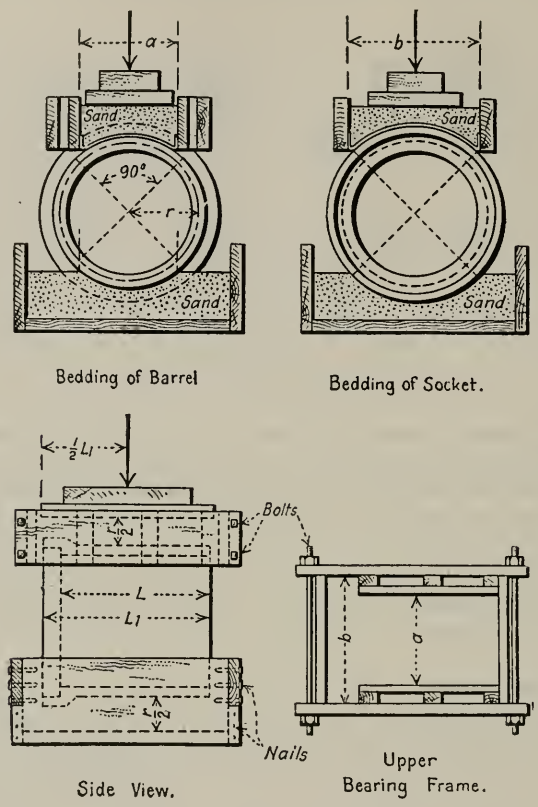


Fig. 2.—Sand Bearings.

(e) The frames of the top and bottom bearings shall be made of timbers with sufficient stiffness that there will be no appreciable bending due to side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

ABSORPTION TEST

19. Test Specimens

The specimens shall be sound pieces, with all edges broken, and may be from pipes tested in the strength tests. They shall be from 12 to 20 square inches in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

20. Identification

Each specimen shall be marked so that it may be identified with the pipe used in the strength test or shipment from which the specimen was taken. The marking shall

be applied so that the pigment used shall not cover more than 1 percent of the total superficial area of the specimen.

21. Number of Tests

One specimen shall be tested of each pipe tested in strength test.

22. Weighing Apparatus

The balance used shall be sensitive to 0.5 g. when loaded with 1 kg. and weighing shall be read at least to the nearest gram. When other than metric weights are used, the same degree of accuracy shall be obtained.

23. Procedure

(a) *Drying Specimens.*—The specimen shall be dried to constant weight in a drier or oven at a temperature of not less than 110 degrees C. (230 degrees F.) After removal from the drier, the specimen shall be cooled in air to temperature of 20 degrees to 30 degrees C. (68 degrees to 86 degrees F.).

(b) *Immersion.*—The specimens shall be placed in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 15 degrees to 25 degrees C. (59 degrees to 77 degrees F.). When cool, the specimens shall be removed from the water and allowed to drain for not more than 1 minute.

(c) *Reweighing.*—The superficial moisture shall then be removed by towel or blotting paper and the specimen immediately weighed.

24. Calculation and Reporting of Results

The absorption shall be calculated as percentage of the initial dry weight. The results shall be reported separately for each individual specimen, together with the average for all the specimens from the same shipment of pipe. The average absorption shall not exceed 8 percent.

ACCEPTANCE OR REJECTION ON RESULTS OF TESTS

25. Strength and Absorption

(a) Failure of 20 percent of the specimens to meet the requirements of the strength tests or the absorption tests or both shall result in rejection of all the pipe in the shipment or delivery, corresponding to the sizes thus failing to comply; except that in the event of 20 percent of the specimens in any size failing to meet the requirements, the manufacturer or seller may, with the consent of the Purchaser, furnish for test, without charge, additional specimens from the same shipment. In case more than 80 percent of the specimens tested, including those first tested, shall show substantial conformance for each of the various tests performed, then the entire shipment or delivery for this size shall be accepted; otherwise it shall be rejected.

(b) *Testing Machine.*—However, in case of failure of pipe to meet the requirements under the specified method, and the accuracy of the testing machine is questioned, a retest at the request of the manufacturer shall be made upon a machine whose accuracy is known or the machine originally used shall be recalibrated before the retest is made.

(c) *Retest after Culling.*—In addition to the requirements in Paragraph (a) failure of 10 percent or more of the individual specimens tested to develop 75 percent of the

average strength requirements shall be cause for the rejection of the shipment; but the manufacturer or seller may cull the pipe and submit the balance of the shipment for retest, and if the shipment then conforms to all of the requirements of these specifications, it shall be accepted.

SIZES, DIMENSIONS AND PERMISSIBLE VARIATIONS

26. Sizes and Dimensions

Pipe shall conform to the dimensions given in Table 1. Where several lengths are shown in the table, the Purchaser shall indicate, at time of purchase, which length shall be furnished. Unless so indicated, the manufacturer may furnish such lengths, shown in the table, as he may elect.

WORKMANSHIP AND FINISH

27. Absence of Defects

Pipes shall be substantially free from fractures, large or deep cracks and blisters, laminations and surface roughness.

28. Salt Glaze

(a) The glaze shall consist of a continuous layer of salt glaze substantially free from large blisters or large pimples. No blisters shall exceed 3 inches in diameter and no blisters or pimples shall project more than ⅛ inch above the surrounding surface of the pipe for sizes up to and including 18 inches in diameter. For sizes over 18 inches in diameter no blisters shall exceed in diameter more than 2 inches per foot of the diameter of the pipe, nor project above the surrounding surface of the pipe more than ⅛ inch per foot of the diameter of the pipe.

(b) Not more than 10 percent of the inner surface of any pipe barrel shall be bare of glaze except the socket, where it may be entirely absent. Glazing shall not be required on the outer surface of the barrel at the spigot end for a distance from the end of the pipe equal to the specified depth of socket. There shall be no well-defined network of crazing lines or hair cracks.

29. Scoring

The inner surface of the socket and the outer surface of the spigot end of pipe shall be scored by triangular shape rings or by circumferential rings about ⅛ inch deep. The minimum number of scorings shall be

Diameter of pipe, inches	6 to 10	12 to 21	24 to 30	36
Number	2	3	4	5

30. Finish of Ends

The ends of the pipes shall be square with their longitudinal axis, except as provided in Table 1.

31. Alinement

Maximum mid-ordinate of pipe intended to be straight shall not exceed ⅛ inch per foot of length.

MARKING, INSPECTION AND REJECTION

32. Marking

Each length of pipe shall bear the initials or name of the person, company or corporation by whom manufactured, the location of the factory, and indicate size of pipe in inches. The markings shall be indented on the exterior of the pipe near the socket and shall be plainly legible for purposes of identification.

33. Inspection

All pipes shall be subject to inspection at the factory, site of project or other point of delivery by a competent inspector employed by the Purchaser. The purposes of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified fail to conform to the requirements of these specifications.

34. Rejection

Pipes shall be subject to rejection on account of the following:

(a) Failure to conform to the dimensions given in Table 1.

(b) Fractures or cracks passing through the barrel or socket except that a single crack at the spigot end of the pipe not exceeding 75 percent of the depth of the socket, or a single fracture in the socket not exceeding 3 inches measured around the circumference, nor 2 inches lengthwise.

(c) Chips or fractures on the interior of the pipe exceeding 2 inches in length, 1 inch in width, and of a depth more than one-quarter of the thickness of the shell.

(d) Blisters which are broken or which exceed the dimensions specified in Section 28.

(e) Fire cracks or hair cracks sufficient to impair the strength, durability or serviceability of the pipe.

(f) Variation of more than ⅛ inch per linear foot in alinement of a pipe intended to be straight.

(g) Glaze which does not conform with these specifications as specified in Section 28.

35. Marking of Rejected Specimens

All pipes accepted may be plainly marked by the inspector. Rejected pipes shall not be marked so as to be defaced or to impair their value, but shall be replaced by the manufacturer or seller with pipes which meet the requirements of these specifications, without additional cost to the Purchaser.

Report on Assignment 5 (b)

Effect of Locomotive Blow Offs on Track Maintenance

H. E. Tyrrell (chairman, subcommittee), F. W. Biltz, W. C. Pruett, L. H. Roden, E. M. Smith, Raymond Swenk.

This is a final report, submitted as information.

With the regular use of chemically treated water in locomotive boilers, it becomes necessary to provide for regular blow offs, as the dissolved solids in the boiler soon reach

a concentration so great, that proper steaming is not possible. Formerly engines were equipped with small blow off cocks on each side of the fire box, discharging directly outward. They were inaccessible, could not be operated from the cab and could only be used when engines were standing. Attempts were made to extend the control of these blow off cocks to the cab, and later, additional blow off cocks were located in the back corners of the fire boxes, with a discharge pipe to an outlet under the cab between the rails, and with a control extending into the cab so that they could be handled by the engineman.

Many variations of manually operated blow offs discharging perpendicularly onto the track, both between and outside the rails, have been used. The results in damage to the ballast and roadbed have been such that the types of discharge apparatus had to be changed so that the discharge was made in a horizontal plane parallel with, or at a very slight angle to the track, toward the rear of the engine, and even this type had to be equipped with a muffler on the outlet to reduce the velocity of the discharge to prevent damage to the ballast and roadbed.

The next development was the continuous blow off, consisting primarily of a discharge line from the boiler fitted with a small orifice restricting the discharge to the volume necessary to keep the boiler water below the foaming point. This type of blow off is manually opened when the locomotive leaves a terminal on its run, and remains open until the run is completed, when it must be manually closed. A development of this type is the automatic continuous blow off, with no manual control. This is a patented device which functions when the throttle is open, automatically closing with the closing of the throttle.

While it is quite a step from the old side blow off cocks to some of the automatic continuous blow off equipment, it has been recognized that the discharge of high pressure steam and water directly at the track is injurious and dangerous to the track. Therefore, devices have been developed to dissipate the force before it reaches the track or ballast, and such devices are now generally used in connection with blowing on the line of road. The most successful of these seems to be a muffler type using the principle of centrifugal force. The muffler is cylindrical in shape; connections from the boiler being made in such a manner that the discharge circulates rapidly in the muffler throwing the water and sludge to the outside walls, where it can drop to the track, at the same time, permitting the steam to escape through the center at the top into the open air.

The problem of blowing off at terminals is more serious, as a regular blowing off at one location deposits large quantities of sludge, fouls the ballast, causes roadbed erosion, and presents serious difficulties during freezing weather. Automatic blowing of switch engines working on the same lead regularly produces like results, therefore, many railroads have installed special arrangements in terminals to eliminate these conditions. One road reports the use of a timber blow off pit in the track, with a grilled top, which has proved effective in taking care of water and sludge, particularly in cold weather. Other roads using the side blow off cocks have constructed wooden blow off boxes adjacent to the track at designated points, the locomotive being spotted with a blow off cock immediately opposite the opening in the blow off box provided to receive the discharge. Baffles are provided in the boxes which cause the solid matter and water to drop to the bottom of the box and be carried off through drain pipes, while the steam is permitted to escape through the top. More elaborate arrangements have consisted of blow off tanks about four feet in diameter and four feet high, buried in the ground with suitable connections so that blow off valve on the engine could be connected to the tank at such an angle that circular motion is set up in the tank, causing the steam to con-

centrate in the center and escape vertically upward through a vent pipe, the heavier water and sludge being thrown against the wall of the cylindrical tank, finally dropping to the bottom where proper sewer connections carries off the water and sludge. In some terminals arrangements are made to connect blow off cocks on engines directly to the blow off facilities of the roundhouse, the discharge being carried to the wash out plant.

Your committee recommends careful consideration of the report of the Committee on Water Service, Fire Protection & Sanitation, Appendix "F", pages 243 to 247, Vol. 40 of the Proceedings, as correspondence with many railroads indicates the soundness of the conclusions on page 247.

Blowing off boilers has in the past caused disturbance of ballast, frequently softened the roadbed, and piled debris, cinder or sludge against one rail of the track where blowing is done, but methods and apparatus have been developed, which if used, will eliminate this trouble, and your committee has therefore, reached the following conclusions:

CONCLUSIONS

1. The blowing of locomotive boilers, either automatically or manually, while in motion on the line of road has no appreciable effect on track maintenance provided engines are equipped with an efficient muffler or dissipating apparatus which prevents the concentration of the discharge directly at the track structure.

2. The regular blowing of locomotive boilers at specified points in yards and terminals will increase the cost of track maintenance unless provision is made for promptly removing the water and solid matter from the track and roadbed.

3. Where switch engines equipped with automatic continuous blow off devices are operated frequently over the same tracks, it is necessary to incur extraordinary labor expense in removing the discharged sediment from the track, as it soon builds up against the rail and interferes with operation. On switching leads, such conditions can be particularly expensive, especially in cold weather when the discharged water and sludge may freeze and cause considerable difficulty in properly maintaining switches.

Report on Assignment 6 (a)

Retaining Structures

(1) Cribbing; Timber, Concrete, Metal
(2) Walls; Dry Rubble, Masonry

G. W. Payne (chairman, subcommittee), G. H. Burnette, F. W. Capp, R. L. Dyke, C. P. Nicholson, M. C. Patton, W. C. Pruett, C. S. Robinson.

This is a progress report, presented as information with the request that the subject be reassigned for further study before recommending approval and publication in the Manual. Comments and criticisms are invited.

603. RETAINING STRUCTURES

Protection of the roadway requires retaining structures in sliding cuts where the slopes cannot be flattened to the angle of repose without the removal of an excessive amount of material or disturbing the ground surface beyond the right-of-way line.

Retaining structures are required also where it is necessary to support all or a part of an embankment slope due to the pressure of a body of water or a deep ravine or the necessity of avoiding encroachments on adjoining property. Protection may be required in special cases such as in laminated rock cuts where there are wet shale or clay seams between the rock ledges, lying on a plane inclined toward the track.

Unless exigencies demand the temporary use of the material that can be most quickly secured, a careful study must be made of each location, paying particular attention to the subsurface conditions, in order to determine the type of structure and kind of material that will best meet the requirements, considering stability, permanency, cost and appearance. Accurate cross-sections and soundings, showing all the conditions to be met, will be necessary in preparing the design.

A. CRIBBING

A popular type of retaining structure is a form of cribbing, in which the crib or cells are filled with a suitable material. Local material, usually earth, may often be used for filling, although better results will be obtained with coarse gravel or rock. Where the crib is subject to action of water, rock of the proper size is essential.

Such a wall gains its stability through the weight of the filling material in the cells plus the weight of the cribbing units.

Crib retaining walls are built of timber, concrete or metal. The longitudinal member in timber and concrete walls is called a "stretcher," the transverse member a "header." Advantages of crib walls are:

1. May readily be erected with unskilled labor and minimum equipment.
2. May be placed on foundation soils which would require piles or caissons under heavy mass walls, since a slight settlement of foundation soil does not damage a properly designed and erected crib wall.
3. Less foundation excavation is required and even this may often be reduced by trenching for the lower part of the crib walls. Under favorable conditions the removal of the top soil to a depth of one foot is sufficient.
4. May be built in short sections, one or two cells at a time, and where the excavated material is suitable it can be used in the preceding crib. This reduces to a minimum the amount of shoring and falsework required and consequent interference with traffic.
5. May be placed in use immediately upon completion of the erection and filling.
6. Units may be salvaged.
7. Usually lower in cost.

There are certain precautions which should be observed in the use of crib walls:

1. Unless the crib members are designed to carry the direct load of a train, the top sections of the wall must be kept from under the ties.
2. While a crib wall will stand more settlement in the foundation soil than a solid wall, care must be taken to secure a sufficiently firm foundation to avoid such uneven settlement as to destroy the alinement, either horizontally or longitudinally or both, with consequent injury to the stability of the wall.

In the design of important crib walls the question of base width should be given the same analytical treatment as for solid walls, to determine the resultant pressures and distribution of pressure over the bed.[1] Experience has shown that in general the following ratios of base width to height may be followed for less important structures where there is a fairly firm foundation.

[1] See Design of Retaining Walls, AREA Manual, pp. 8–56 and 8–82.

(a) With little or no surcharge usually provide 50 percent, minimum 45 percent.

(b) With slight surcharge but super-imposed traffic loads 50 percent to 65 percent, depending upon the traffic load, highway or railroad, and the distance of the traffic load from the crib wall.

(c) With heavy surcharge at least 65 percent.

(d) The width at top and bottom should not be less than 4 feet.

Where double-header or double-cell construction is used to gain the necessary base width (See Fig. 2) the double cell should be carried well above the slippage plane and always above the ⅓ point in the height of the wall. This practice will largely eliminate the bulges sometimes seen just a little above the ground line in crib walls over 10 feet high.

Crib walls may be built to any desired batter, or even vertical. The batter most generally used and recommended is 1 in 4 for timber and 1 in 6 for concrete and metal. If less batter is used the width must be increased sufficiently to have the resultant pressures fall within the middle third of the base. The desired batter may be secured by placing the base on a slope equal to the batter, or with high walls, it is often economical to use a stepped foundation, placing the toe on sills, which does not require that the depth of heel be governed by the batter.

The front and rear walls of the cribs should be connected at each panel point.

The crib wall is essentially a flexible structure and should be free to move in any direction to adjust itself to reasonable settlement and thrust movement without structural failure.

Nearly all failures of crib walls, other than the bulges noted above, are due to unequal settlement of the foundation, to shrinkage of the backfill material, or to a combination of these causes. Earth backfill material within the cells should be evenly spread in horizontal layers and well tamped. The backfilling behind the wall should be well tamped and should be kept near, but not above, the level of the compacted material within the cells. Where existing slopes are to receive additional fill material they should be benched or stepped to reduce the load on the retaining structure. Unequal settlement of the foundation in amounts that may be serious can be avoided by (a) carrying the foundation to firm strata, or where this is not possible by (b) using additional rows of bottom stretchers to distribute the load.

Timber

Fig. 1 shows a typical timber crib retaining structure. Creosoted preframed timber is recommended except for temporary installations, or when constructed as a matter of expediency. Salvaged treated timbers have been used to form an economical and suitable structure.

The wall may be stepped at the back above the ⅓ point in height, as shown in Fig. 1 (a), for heights where the saving in timber will warrant. The structure in Fig. 1 however will have greater stability.

One of the structural advantages of timber cribbing is that the compressibility of the timber permits adjustment in the finished structure to meet unequal foundation settlement.

It is not customary to provide for any drainage back of timber crib walls.

Concrete

Precast reinforced concrete cribbing dates back to 1915 or earlier. There are a number of different types on the market. Each manufacturer has his own design and units made by one are not interchangeable with those made by another. Most manufacturers

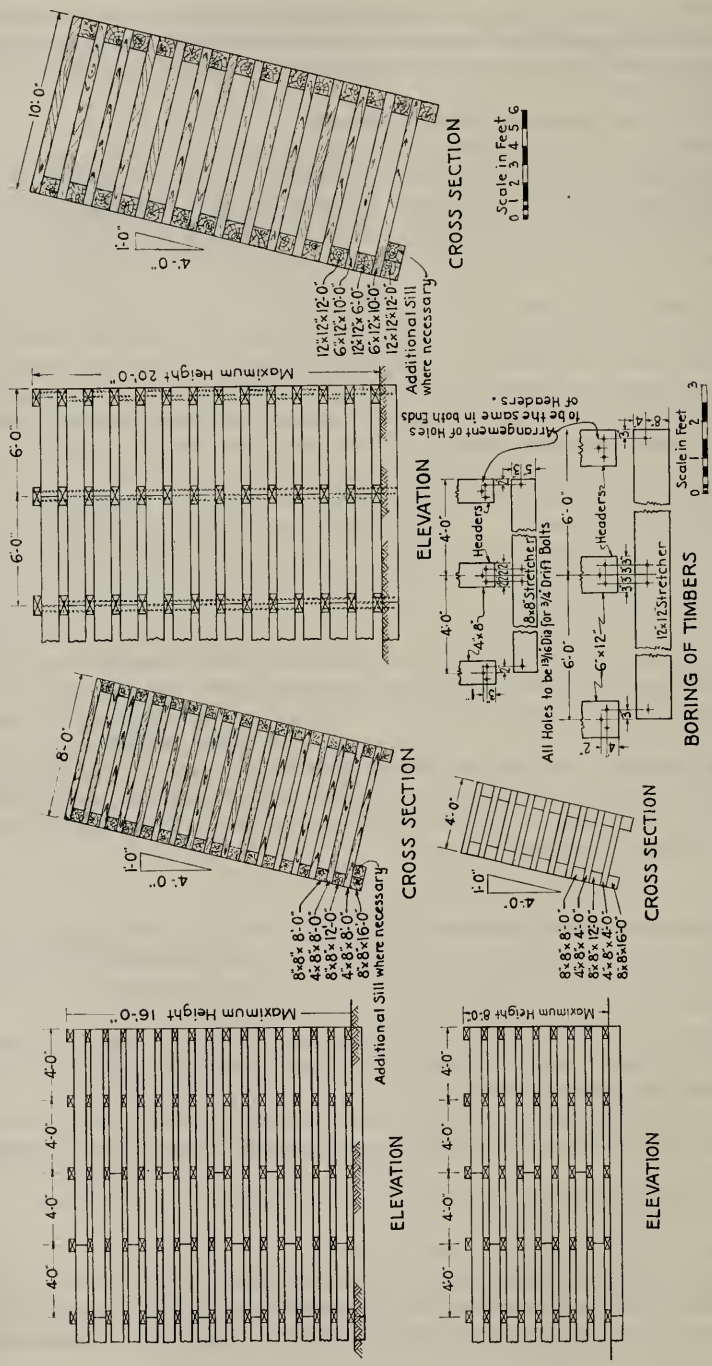


Fig. 1.—Typical Timber Crib Wall.

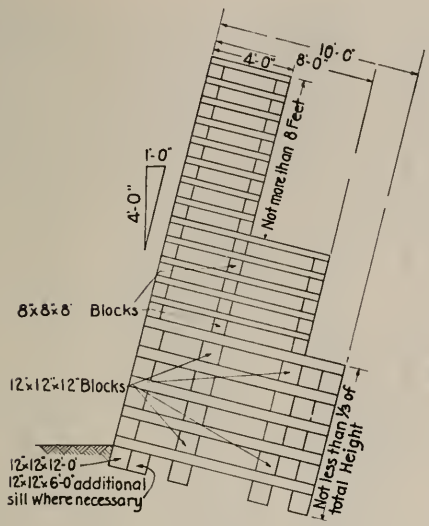


Fig. 1a.—Cross Section.

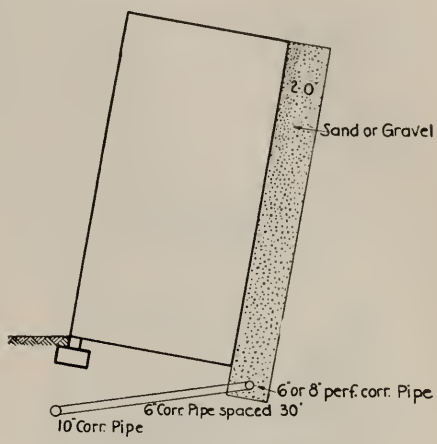


Fig. 1b.—Method of Draining Back of Crib Wall.

make both open and closed face cribbing. Some railroads have their own design and make the units in their own pre-casting yards.

Fig. 2 shows a concrete crib wall manufactured and used on a mid-western railroad. By omitting the front filler blocks this type is adaptable to both open and closed faces. The cross-section of the stretcher in this design permits a considerable saving in stretcher area for open face walls.

Concrete crib walls present a nice appearance and have been used with marked success on many railroads to meet a wide range of conditions. The following general principles should be followed in the manufacture of the units:

1. The units should be of sufficient size and strength to resist bending, shear and bearing in service and breakage in handling.
2. Their size and weight should be such that they can be handled and placed without special equipment. Loading, unloading and stacking should be carefully done to prevent damage.
3. The concrete should conform to specifications for 3,500-pound unit stress concrete. All reinforcing steel should be so located that it will be protected by at least ¾ inch of concrete, preferably 1 inch.

The material for backfilling should not contain any ingredient injurious to concrete.

In comparing the different designs of concrete cribbing, consideration should be given to other things than the cost of the units, as follows:

1. The number of units required.
2. The size and weight of units.

These influence the erection cost.

Where there is seepage back of crib walls some provision for drainage is necessary except where the drainage is permitted to come out through open faced walls. An example of adequate provision for intercepting seepage is shown in Fig. 1b. A layer of sand,

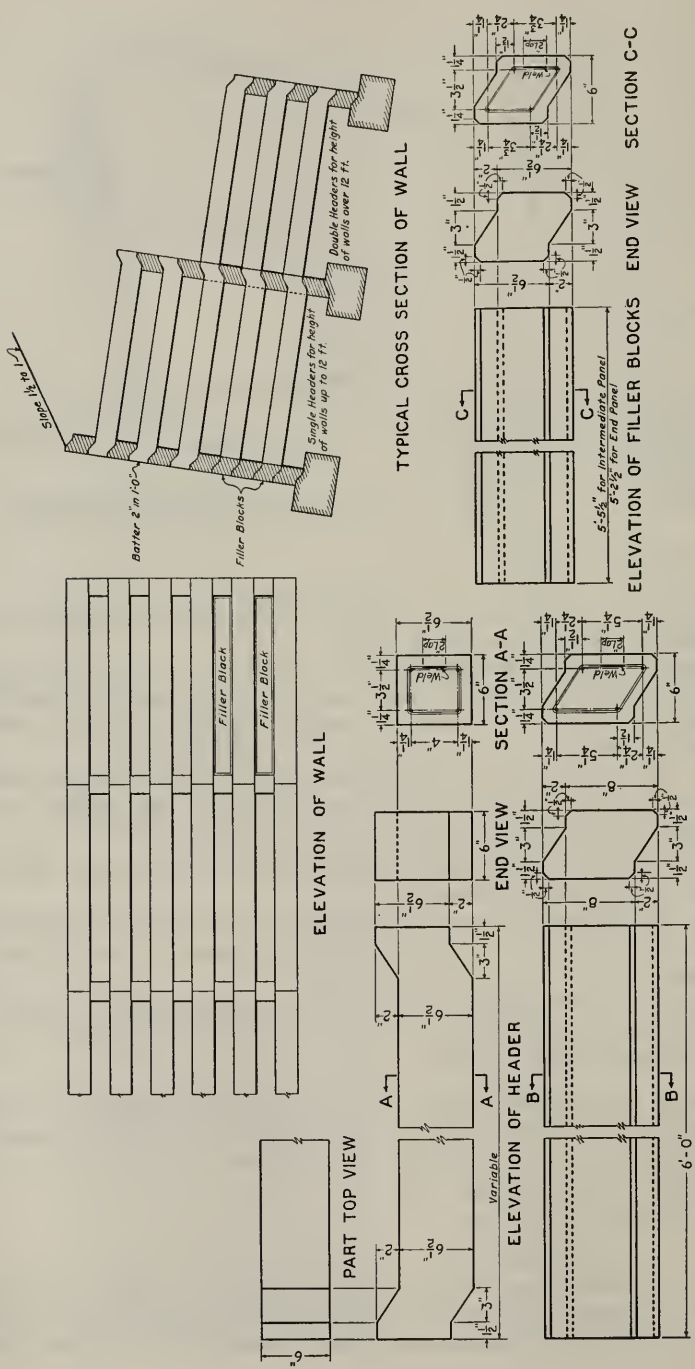


Fig. 2.—Typical Concrete Crib Wall.

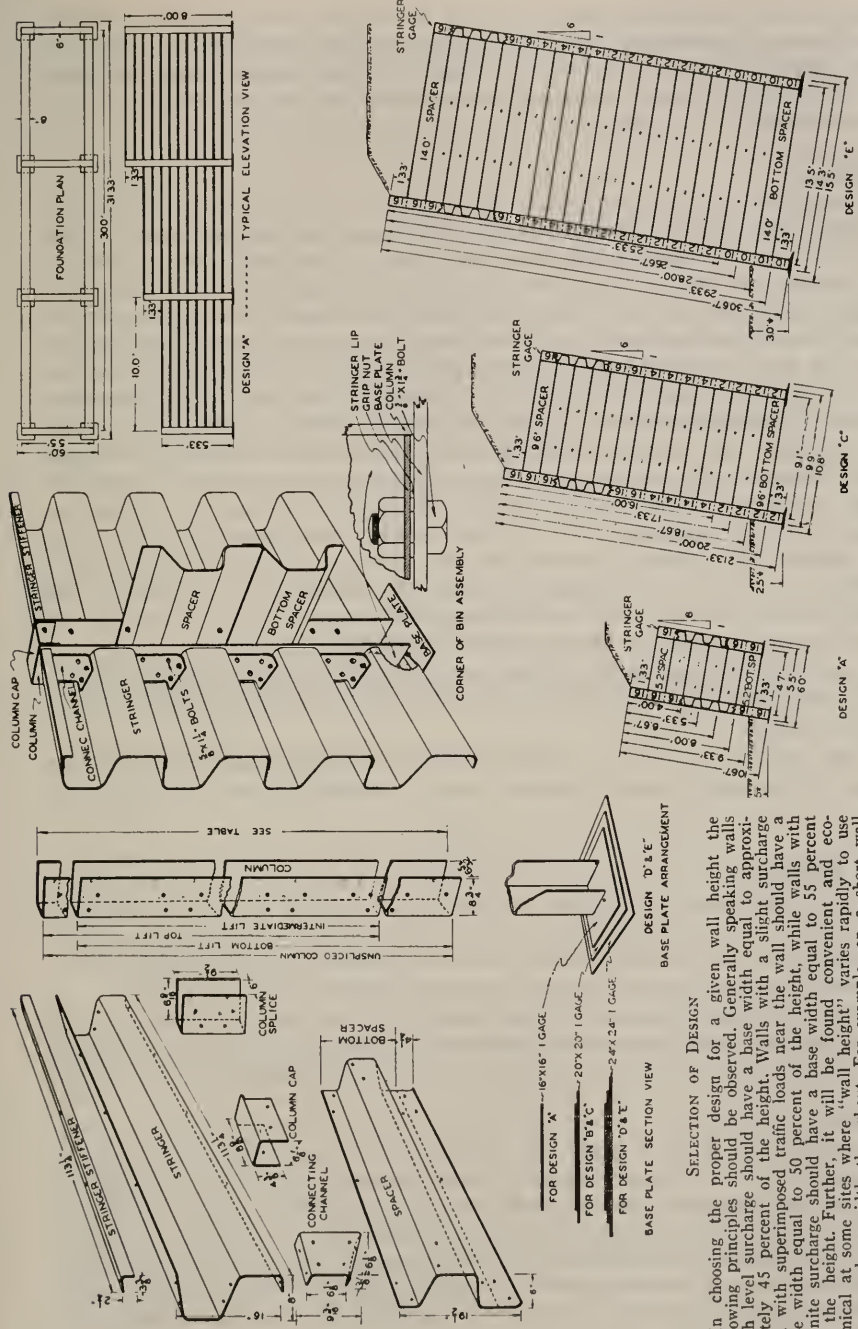


Fig. 3.—Layout of Typical Designs and Standard Units for Bin-Type Metal Retaining Walls.

Selection of Design

In choosing the proper design for a given wall height the following principles should be observed. Generally speaking walls with level surcharge should have a base width equal to approximately 45 percent of the height. Walls with a slight surcharge but with superimposed traffic loads near the wall should have a base width equal to 50 percent of the height, while walls with infinite surcharge should have a base width equal to 55 percent of the height. Further, it will be found convenient and economical at some sites where "wall height" varies rapidly to use the same base width throughout. For example, on a short wall that ranges in height from 8 to 16 ft. the use of Design "B" for the entire distance is suggested, even though Design "A" might be sufficient for part of the wall.

gravel or other permeable material is placed at the back of the wall to carry the drainage down to the longitudinal drain near the base. For long walls there is a cross drain outlet under the base every 30 feet, connecting to a 10-inch corrugated pipe in front of the wall. With this plan, if drainage becomes blocked at any point back of the wall there will always be an outlet to the front on either side of the block.

Metal

Galvanized iron has been used in the manufacture of box-shaped cribbing units, patterned after concrete cribbing, since 1930. A few years later the galvanized iron bin-type retaining wall shown in Fig. 3 was developed. In this construction the units do not overlap each other at the corners as the usual cribbing units do, but instead the stringers and spacers are securely bolted to rigid U-shaped corner columns. The bins are thus completely enclosed on all four sides. The solid transverse sections acting as beams carry the load to the corner columns, and thence directly to the base. This is said to increase the strength and stability of the wall. Ability of the structure to adjust itself to unequal foundation settlement is gained through the flexibiliy of the individual units.

Experience with this type of wall in railway use indicates that the relatively light weight, nestable units are especially adaptable to installations adjacent to heavy rail traffic. The gage of metal is varied to meet the loading conditions, the lightest gage being No. 16 and increasing to No. 10, except that all corner columns are No. 8 gage. The heaviest unit weighs 150 pounds. Since the units are nestable, minimum space is required for shipment and storage. Only single bin construction is used for all wall heights; that is, the base width is carried completely to the top, thus assuring that all the filling material above the base is available for stability of the wall.

Care should be taken in the handling and placing of the units to avoid damage and loss of any galvanizing. The backfill material should not contain any elements detrimental to metal.

With this type of structure some provision for drainage back of the wall will usually be necessary. It may be handled about as outlined for concrete crib walls.

B. WALLS

Dry Rubble

Dry rubble walls are in general recommended for railroad use only for low walls to maintain toe of slopes, ditch lines in narrow cuts and around the ends of pipe culverts when the stone is readily available. They may, however, be built cheaply and to a considerable height if properly designed and carefully laid.

The wall should be founded at such depth that it will not be disturbed by frost action, and will secure proper resistance from the soil in front of it. The stones should be selected to lay tight and bond, the larger voids being filled with spalls.

Masonry

Dressed stone is not so much used for retaining walls as in years past due to development of concrete designs of equal or greater strength at less cost and to the scarcity of skilled workmen to cut and lay up the stone properly. Under present conditions, the principal reason for considering dressed stone masonry walls is a matter of esthetics, such as, for example, the extension of an existing masonry wall where from an appearance standpoint it is desirable to have the extension as nearly like the existing wall as possible; or where it is desired to have the wall conform in appearance to nearby stone buildings or other structures.

Concrete

Concrete retaining walls may be designed to meet the most rigid and variable requirements, and are selected for the most restrictive locations, such as in cities where maximum use of the land is required, where excavation for gravity walls is prohibitive due to solid rock or other conditions, or where a pile foundation is necessary.

Reinforced concrete walls are constructed in various types of which the cantilever, counterfort and L-section designs are the most common. The base may be entirely in front of or entirely back of the face, or it may be partly in front and partly back of the face. Field investigations should include sufficient information to enable the designer to determine the limits within which the wall should be built.[2]

Hydrostatic pressure must be avoided back of the wall insofar as possible. The back should be given an approved waterproof coating. A layer of sand, gravel or other permeable material should be placed between the back and the fill material to carry the drainage down. A longitudinal drain should be placed on the top of the base and four-inch weep holes provided at intervals of 15 to 20 feet to carry the drainage to the face of the wall. In counterfort walls a weep hole should be provided in each space between counterforts. The weep holes should be connected with a drain along the front of the wall, and the front fill should also be carefully drained.

Report on Assignment 7

Tunnel Maintenance

W. S. Moore (chairman, subcommittee), F. W. Alexander, H. F. Brown, F. W. Hillman, G. B. Wall, Jr.

This is a final report submitted as information.

General

Restrictions of light and space as well as specific traffic conditions create, in tunnel maintenance, peculiar conditions under which work must be performed. It is, therefore, recommended that men, specially trained and experienced in tunnel maintenance, be employed.

Track Maintenance in Tunnels

The roadbed in the early type of tunnel, with the track resting on an unprepared subgrade, is a frequent source of trouble. Alternate outcroppings of stone and earth coupled with inadequate drainage of ground water create conditions favorable to soft spots and water pockets. In some of the modern tunnels concrete floors have been installed to relieve this condition. Even here inadequate drainage of ground water has made it necessary to pressure grout the subgrade in an attempt to solidify the foundation. In floorless tunnels it is probable that grouted ballast would accomplish much the same results.

Ballast.—Ballast maintenance in tunnels is more expensive than in stretches outside. Cinders from coal burning locomotives, ordinarily scattered over the right-of-way, are confined, in a tunnel, to the ballast and ditches. Ventilating fans and draught from moving trains blow loose material from the tops of cars and increase the fouling of ballast and clogging of ditches. Dirty ballast is difficult to dispose of and track cannot be

[2] Ibid.

raised because of the limited clearance. In some newer tunnels a Bush type track, having short ties embedded in concrete with drainage between the rails, is used to eliminate ballast and ballast troubles. Rails clipped directly to a concrete base would provide an alternate method.

Ties.—Ties are difficult to replace in tunnels because of insufficient side clearance. The Bush type track would require a mason force for replacement as the short ties must be grouted in place. Rails clipped directly in the concrete base eliminate ties, but increase the amount of fastenings.

Rail and Fastenings.—The chemical action of locomotive gasses on rails, fastenings, and other metal material in tunnels is being studied by the Track committee.

Maintenance of Tunnels

Unlined Tunnels.—The frequency of scaling operations in unlined tunnels is indicated largely by experience with the particular formation and condition of the rock through which the tunnel is constructed. All material that appears to be loose should be removed. If work is not extensive this can be done with bar and wedges. Paving breakers give good results in heavy work and frequently obviate the necessity for blasting. Explosives, even in small charges, should be used only as a last resort. Where scaling is frequent or costly it may be economical to line the tunnel.

Direct blast from locomotives may cause considerable damage where the rock is soft. Consequently when an engine stalls in a tunnel a prompt report should be made giving the location so that a special inspection can be made.

Some roads use special devices on the locomotive to prevent the direct blast from the locomotive from striking the roof.

Timber Lined Tunnels.—Repairs to timber lined tunnels should be made by a competent experienced carpenter force. Although patch renewals are frequently justified, it is usually more economical to renew complete sections with preframed treated timber. The moist condition of most tunnels reduces the fire hazard. The use of special salt may further reduce the hazard.

Masonry Lined Tunnels.—Properly constructed concrete tunnels should be practically maintenance free. Direct blast and gasses from locomotives may cause some surface disintegration, particularly near the ends of tunnels where the concrete is also subject to alternate freezing and thawing.

Minor repairs can be made with shotcrete. Poor concrete or advanced disintegration is a subject for the specialist.

Brick lined tunnels present much the same problem as concrete lined.

Special Maintenance Items

Clearance.—Many of the older tunnels provide little more than safe clearance for modern cars and engines. Instructions should be issued prohibiting any unauthorized raise in grade, change in alinement or superelevation. Permanent reference points should be established and regular checks made to see that instructions have been obeyed.

Drainage.—It is necessary to clean the ditches frequently to remove cinders and other debris so that water may flow freely. In the winter, near the portals, water will freeze in the ditches and block drainage. To remedy this, it is advisable to install some sort of subsurface drainage to carry the water off without allowing it to freeze.

Inspection

Inspection of tunnels, a necessary prelude to proper maintenance, requires sufficient light, a car suitably equipped, and men familiar with the work.

Inspections should be made at definite intervals and recorded in complete written reports of the conditions observed with special notice of changes since the last inspection.

The inspection car is a car on which scaffolding has been erected to hold platforms at suitable heights so that all parts of the tunnel may be reached. A ladder should be constructed in the frame work to provide access from the floor of the car to the platform. Substantial railings should be provided around the platforms. The entire superstructure may be bolted together in such a manner that it can be taken down and shipped to other points.

Weather Conditions.—Extreme cold causes heavy maintenance expense due to the formation of icicles and the freezing of water in ditches. To alleviate this some roads in severe climate use light doors, covered with canvas, at the portals. These doors are kept closed in severe weather except for passage of trains. The doors must be left open after the train passage until the smoke clears.

Watchmen.—Watchmen are frequently employed in tunnels where conditions justify it. It is usually more economical to correct the condition by more frequent scaling or by lining the tunnels.

References

A series of six articles on Tunnel Equipment and Construction—Engineering News-Record, Dec. 24, 1931;

Tunnel Grouting at Cobble Mountain—Engineering News-Record, Dec. 31, 1931;

Excellent Plant Expedites Tunnel Lining on Illinois Central—Railway Age, Feb. 23, 1935;

Denver & Salt Lake Lines Moffat Tunnel with Concrete—Railway Age, Nov. 16, 1935;

Reinforced Concrete Lining Used to Advantage in Old Tunnel—Engineering News-Record, Aug. 15, 1936;

Specifications for Lining Railway Tunnels with Plain Concrete—AREA Manual 1936;

Restore Concrete Tunnel Lining by Intrusion Process—Railway Age, Mar. 4, 1939; Railway Engineering and Maintenance, Feb. 1936; Apr. 1941.

Report on Assignment 8 (a)

Corrosion Resisting Fence Wire

Collaborating with Appropriate Subcommittees of Committee A-5 on Corrosion of Iron and Steel ASTM

A. R. Jones (chairman, subcommittee), F. W. Hillman, W. C. Pruett, P. H. Winchester.

Your committee is collaborating with and receiving reports of the exposure tests of farm field fence, unfabricated wire, wire strand, barbed wire and chain link fencing of ASTM Committee A-5 on Corrosion of Iron and Steel. The progress of this test is reported in ASTM proceedings as follows:

Proceedings of 1934, Vol. 34, page 167, Proposed Field Test of Wire and Wire Products.

Proceedings of 1937, Vol. 37, page 117, Report of Wire Test Committee; page 122, Appendix to Report of Wire Test Committee.

Proceedings of 1939, Vol. 39, Final Report of Wire Test Committee; page 103, Micrographs and Characteristics of Specimens of Unfabricated Wire, Farm Field Fence and Barbed Wire; page 150, Methods of Testing; page 156, Report of Wire Test Inspection Committee on Field Tests of Wire and Wire Products.

Proceedings of 1940, Vol. 40, page 97, Subcommittee VIII on Field Tests of Wire and Wire Products reports as follows:

Inspection made since last published report (Proceedings ASTM Vol. 39, page 156, 1939) shows further rusting of the lighter weight zinc-coated wires at Pittsburgh, Pa., Sandy Hook, N. J. and Bridgeport, Conn. No rusting has taken place in the groups carrying coatings heavier than 1.0 oz. per sq. ft. at Pittsburgh or heavier than 0.45 oz. per sq. ft. at Sandy Hook. At State College, Pa. and at the remaining seven sites no rust has appeared on any coated wires.

The samples exposed for the determination of loss of tensile strength are being periodically removed and tested. Final trends of strength loss tests will be published when sufficient data have been assembled.

Concerning the zinc-coated specimens that were exposed for the purpose of periodic removal in order to determine the loss of weight of coating, the status is as follows: All samples have been removed from the Pittsburgh test site and some have been removed from Sandy Hook and State College. The annual losses of weight now indicated are

0.369 oz. per sq. ft. for Pittsburg.
0.119 oz. per sq. ft. for Sandy Hook.
0.071 oz. per sq. ft. for State College.

Specimens to determine the loss of weight of coating were not exposed at any of the other sites.

Report on Assignment 8 (b)

Wood Fence Posts, Specifications, Etc.

A. R. Jones (chairman, subcommittee), F. W. Hillman, W. C. Pruett, P. H. Winchester.

Last year your committee presented for consideration as information Specifications for Wood Fence Posts. Revisions have been made to comply with recommendations received and the specifications as presented below are submitted with the recommendation that they be adopted and printed in the Manual.

VIII FENCES

801. FENCE POSTS AND BRACES

A. SPECIFICATIONS FOR WOOD FENCE POSTS

MATERIAL

1. Kinds of Wood

Purchaser in the order for posts shall state which of the following woods will be acceptable. In the absence of such information manufacturer may furnish posts made from any of the woods listed.

Class U designates the kinds of wood that may be used untreated and Class T designates the kinds of wood which should receive preservative treatment.

Class U		*Class T*	
Black Locust	Black Walnut	Ash	Hackberry
Cypress	Heart Yellow Pine	Beech	Maple
Catalpa	Larch	Birch	Red Oak
Cedar	Red Mulberry	Black Gum	Sap Yellow Pine
Chestnut	Redwood	Cherry	Sycamore
Douglas Fir	White Oak	Elm	Sap Fir
		Hickory	

PHYSICAL REQUIREMENTS

2. Defect*

Posts shall be free from the following defects: Decay, excessive crook, wane on rectangular posts, holes in top of post, numerous holes, large knots, large shakes and splits.

3. Defects Allowable*

In round cedar posts, pipe or stump rot up to 0.75 inches in diameter in butt end.

Peck in cypress up to limitation of holes.

Crook that does not exceed 3 inches measured between the longitudinal axis and a straight line from the center of one end to the center of the other end.

Wane on rectangular posts not exceeding one-fourth of the dimension of the faces.

Holes other than in top of post not exceeding 1 inch diameter and 3 inches deep.

Numerous holes that are not damaging in effect.

Knots in round posts whose average diameter is less than one-third the diameter of post.

Knots in rectangular posts whose average diameter is less than 0.25 the width of surface in which the knot appears.

Numerous knots that are not damaging in effect.

Large shakes in rectangular posts whose maximum dimension between parallel lines does not exceed 0.25 of the minimum thickness of post.

In round posts shakes not damaging in effect.

Splits not damaging in effect.

DESIGN

4. General

Posts shall be of the size and dimensions specified in the order.

5. Dimensions

All posts shall be in accordance with the designs and dimensions shown in the Table.

MANUFACTURER

6. General Requirements

All posts shall be straight, well manufactured, of natural taper, free from projections and cut square at ends unless small end is roofed. Inner skin must be removed and roofing or gaining of treated posts shall be done before treatment.

* For definition of terms please see "Definitions of Maximum Defects and Blemishes" Manual page 7–74.

DESIGN AND DIMENSIONS OF FENCE POSTS

Design	Dimensions: Intermediate or Line Posts, At Small End	Intermediate or Line Posts, Length	End, Corner, Anchor and Gate Posts, At Small End	End, Corner, Anchor and Gate Posts, Length
Round	4 in. diameter	7 ft.	8 in. diameter	8 ft.
	5 in. diameter	8 ft.		
Rectangular	4 in. by 4 in.	7 ft.	8 in. by 8 in.	8 ft.
	5 in. by 5 in.	8 ft.		
Halved	19 in. Perimeter	7 ft.		
	21 in. Perimeter	8 ft.		
Quartered	19 in. Perimeter	7 ft.		
	21 in. Perimeter	8 ft.		

INSPECTION

7. Place

Posts shall be inspected at points of shipment or destination, in suitable and convenient places satisfactory to the railroad. Posts will be inspected at points other than the railroad property whenever in the judgment of the railroad there is sufficient number to warrant it; but the shipper shall provide accommodations for the inspector at the expense of the railroad, while away from rail or steamship lines, and transport him from and to a railroad station or steamer landing.

8. Manner

Inspectors will make a reasonably close inspection of each post, which shall be judged independently, without regard for decisions on others in the same lot. Posts too soiled for ready examination will be rejected. Posts shall be turned over as inspected.

WORKMANSHIP

9. Tolerances

Posts shall not be more than 1 inch shorter nor 3 inches longer than the lengths specified.

Posts shall not be more than ¼ inch smaller nor more than 1 inch larger than the diameters, widths and perimeters specified.

DELIVERY

10. Separated as Specified

Posts shall be separated according to the kind of wood, shape and size or as may be required in the order for them.

PRESERVATIVE TREATMENT

11. Specifications

Posts requiring treatment shall be treated in accordance with the AREA Specifications for the Preservative Treatment of Wood.

Report on Assignment 12

Special Ballast: Investigate the Use of Asphalt in Ballast

J. M. Podmore (chairman, subcommittee), J. A. Given, J. A. Noble, Stanton Walker, C. S. Wicker.

This is a progress report and is submitted as information.

On the New York Central Railroad, in the early fall of 1939, a 600 ft. test section of emulsified asphalt coated stone ballast was installed in the eastbound high speed track at the Bryan, Ohio, passenger station platform. A complete account of this test appears in previous reports of the committee.

No work was performed on this test section of track since August 1940, until September 1941, when a foreman and two laborers worked a total of 60 hours for the foreman and 120 hours for the laborers. In making repairs 150 gal. of emulsified asphalt was used and one cub. yd. of sand. This force spent one-half day, or four hours, brushing or clearing off the top of the asphalt or carpet coat. This is included in the above time. They removed about three wheelbarrows of fine cinders, dirt and foul material.

It was found that the sand and asphalt seal was cracked in a few places between the crossties, and the seal coat in these places was repaired. The bond between the seal coat and the edges of the crossties in some places had separated. These were refilled with asphalt and sand. There were five low joints and two low rails. The seal coat and the asphalt coated ballast were dug out. These low places were raised to the proper grade, the crossties retamped, the asphalt coated stone and the carpet or seal coat were then replaced. The asphalt coated stone ballast under the seal coat was readily workable and not hard and brittle. The asphalt coated ballast could easily be tamped after being in the track since the fall of 1939.

The test section of track has remained in very good condition since installed. The line and surface are good, the water sheds off quickly after storms, and there is no foul ballast. The seal coat retains all foreign matter and prevents it getting into the ballast.

Over the easterly end of this test section there is a fairly heavy travelled highway crossing paved with creosote plank.

Since completion there has been no heaving during the winter on any portion of the 600-ft. length of test track, but heaving occurs beyond either end of the test section and on the adjacent tracks during the winter.

To date the test has proved satisfactory.

Report of Committee 5—Track

W. G. Arn, *Chairman,*
Lem Adams
L. L. Adams
C. W. Baldridge
A. L. Bartlett
W. H. Bettis
F. J. Bishop
L. H. Bond
W. S. Boyce
C. W. Breed
E. W. Caruthers
Armstrong Chinn
H. R. Clarke
O. U. Cook
W. E. Cornell
E. D. Cowlin
H. Q. Day
L. W. Deslauriers
J. A. Ellis
H. F. Fifield
J. W. Fulmer
R. A. Gravelle
H. H. Harman
N. M. Hench
F. W. Hillman
J. V. Houston
E. T. Howson
A. F. Huber
W. G. Hulbert
C. T. Jackson
F. J. Jerome
A. A. Johnson
J. H. Kelly
J. de N. Macomb
G. M. Magee
E. E. Martin
L. I. Martin
F. H. Masters
K. R. McLennan
R. E. Miller
J. B. Myers
A. E. Perlman, *Vice-Chairman,*
G. A. Peabody
S. H. Poore
J. A. Reed
O. C. Rehfuss
D. B. Rice
C. J. Rist
W. L. Roller
I. H. Schram
J. F. Shaffer
G. L. Sitton
G. J. Slibeck
G. M. Strachan
C. R. Strattman
Hermann von Schrenk
H. N. West
R. P. Winton
J. G. Wishart
M. J. T. Zeeman
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, embracing a number of recommended revisions ..... page 516
   For other revisions see Assignments 3 and 4 (a).

2. Fastenings for continuous welded rail, collaborating with Committee 4—Rail.

   No report.

3. Plans and specifications for track tools and recommended minimum limits for reclaimed tools, collaborating with Committees 1—Roadway and Ballast, and 22—Economics of Railway Labor.

   Progress report, including recommendations for revision of the Manual ... page 519

4. (a) Plans for switches, frogs, crossings, spring and slip switches, collaborating with Signal Section, AAR.

   Progress report, including plans submitted for adoption ..... page 522
   For plans previously published during 1941–42, see Bulletin 427, page 107.

4. (b) Track construction in paved streets, collaborating with Committee 9—Highways.

   No report.

5. Photoelastic study of stresses in tie plates.

   Progress report—presented as information ..... page 539

6. Design of tie plates for RE rail sections as developed, collaborating with Committees 3—Ties, and 4—Rail.

   Progress report—presented as information ..... page 547

7. Practicability of using "reflex" units for switch lamps and targets, collaborating with Committee 10—Signals and Interlocking.

   Final report—submitted as information ..... page 548

8. Welding of manganese castings in special trackwork, collaborating with Committee 27—Maintenance of Way Work Equipment.

   Progress report—presented as information ..... page 549

9. Bolt tension necessary for proper supporting of rail joints.

   Progress report—presented as information ..... page 550

10. Lubrication of rail on curves, collaborating with Committee 16—Economics of Railway Location and Operation.

    No report.

11. Prevention of damage due to brine drippings on track and structures, collaborating with Mechanical Division, AAR.

    Progress report—presented as information ..... page 566

12. Report on special assignment—testing.

    No report.

13. Specifications for high-carbon steel track spikes.

    Proposed specifications—presented as information ..... page 570

The Committee on Track,
W. G. Arn, *Chairman.*

Report on Assignment 1

Revision of Manual

M. J. T. Zeeman (chairman, subcommittee), L. L. Adams, C. W. Breed, Armstrong Chinn, H. R. Clarke, J. A. Ellis, R. A. Gravelle, E. T. Howson, A. A. Johnson, J. H. Kelly, J. de N. Macomb, I. H. Schram, J. G. Wishart.

The committee submits the following revisions for adoption:

Page 5–1

Change title of this specification to read:

Specifications for Medium-Carbon Steel Tie Plates

Delete the paragraph directly below "1941", which states that this specification covers two grades of steel.

Section 201 (c)—Delete the last four lines, and in lieu thereof insert the following two lines:

Bessemer—not under 0.12 percent.
Open-hearth—not under 0.20 percent.

Page 5–2

Section 301—Delete the text of this section, and in lieu thereof insert the following:

301. The bend test specimens specified in Section 302 shall stand being bent cold through 180 degrees around a pin the diameter of which is equal to twice the thickness of the specimen without cracking on the outside of the bent portion.

Section 303—Delete the last four lines describing the alternate bend test, and in lieu thereof insert the following:

> A piece of the rolled bar shall bend cold through 90 degrees around a pin the diameter of which is equal to twice the thickness of the section where bent without cracking on the outside of the bent portion.

Pages 5–2 and 5–3

Delete the entire text under "IV Workmanship and Finish", consisting of Section 401 on page 5–2 and Sections 402 and 403 on page 5–3; and in lieu thereof insert the following sections, retaining the present heading:

401. The tie plates shall conform to the dimensions specified by the Purchaser, with the following permissible variations:

(a) For tie plates with shoulders parallel to the direction of rolling, a variation of $\frac{1}{32}$ inch over or $\frac{1}{32}$ inch under in thickness, $\frac{1}{8}$ inch over or $\frac{1}{8}$ inch under in rolled width, and $\frac{3}{16}$ inch over or $\frac{3}{16}$ inch under in sheared length.

(b) For tie plates with rolled crown, a variation of $\frac{1}{32}$ inch over or $\frac{1}{32}$ inch under in thickness, $\frac{3}{16}$ inch over or $\frac{3}{16}$ inch under in rolled width, and $\frac{1}{4}$ inch over or $\frac{1}{4}$ inch under in sheared length.

(c) A variation of 0.025 inch over or 0.025 inch under in flatness of rail seat.

(d) A variation of $\frac{1}{16}$ inch over the minimum dimension specified for distance between the shoulders of double shoulder tie plates.

(e) A variation of $\frac{1}{32}$ inch over or $\frac{1}{32}$ inch under in the location of spike holes and in the length or width of their sides.

402. The tie plates shall be smoothly rolled, true to templet, and free from injurious warp and other imperfections in surface and projecting fins of metal caused by shearing and punching.

403. Tie plates shall be paid for on the basis of actual weight as applied to the entire order, except that payment shall not be made for any weight in excess of 3 percent over the weight calculated from the specified dimensions.

Page 5–14.1

Section 201. Following the two lines showing carbon and phosphorus content, insert the following:

Copper, when specified, minimum percent 0.20

Page 5–14.2

Delete the entire text under "IV Workmanship and Finish", consisting of Sections 401 and 402, and in lieu thereof insert the following sections, retaining the present heading:

401. The tie plates shall conform to the dimensions specified by the purchaser, with the following permissible variations:

(a) For tie plates with shoulders parallel to the direction of rolling, a variation of $\frac{1}{32}$ inch over or $\frac{1}{32}$ inch under in thickness, $\frac{1}{8}$ inch over or $\frac{1}{8}$ inch under in rolled width, and $\frac{3}{16}$ inch over or $\frac{3}{16}$ inch under in sheared length.

(b) For tie plates with rolled crown, a variation of $\frac{1}{32}$ inch over or $\frac{1}{32}$ inch under in thickness, $\frac{3}{16}$ inch over or $\frac{3}{16}$ inch under in rolled width, and ¼ inch over or ¼ inch under in sheared length.

(c) A variation of 0.025 inch over or 0.025 inch under in flatness of rail seat.

(d) A variation of $\frac{1}{16}$ inch over the minimum dimension specified for distance between the shoulders of double shoulder tie plates.

(e) A variation of $\frac{1}{32}$ inch over or $\frac{1}{32}$ inch under in the location of spike holes and in the length or width of their sides.

402. The tie plates shall be smoothly rolled, true to templet, and free from injurious warp and other imperfections in surface and projecting fins of metal caused by shearing and punching.

403. Tie plates shall be paid for on the basis of actual weight as applied to the entire order, except that payment shall not be made for any weight in excess of 3 percent over the weight calculated from the specified dimensions.

These proposed changes are recommended in order to bring the specifications for tie plates up to date. It should be noted that it is proposed to eliminate the soft grade of tie plates from the specifications on page 5–1 now covering two grades of steel; therefore, if this revision is approved, these specifications would cover the medium-carbon steel plates only. The other proposed changes are recommended so as to harmonize the permissible tolerances in the medium-carbon and the high-carbon steel tie plate specifications.

Pages 5–11, 5–12 and 5–13

Delete the Specifications for Wrought Iron Tie Plates.

In the opinion of the committee the very limited use, at the present time, of wrought iron tie plates does not warrant the retention of specifications in the Manual.

Glossary—Page 29

Main track. Delete the present definition, and in lieu thereof insert the following:

MAIN TRACK.—A track extending through yards and between stations, upon which trains are operated by time table or train order, or both, or the use of which is governed by block signals. *5*

The reason for this change is the desirability of having the same definition in the AREA Manual as in the Standard Code of the AAR.

Report on Assignment 3

Plans and Specifications for Track Tools and Recommended Minimum Limits for Reclaimed Tools

Collaborating with Committees 1—Roadway and Ballast and 22—Economics of Railway Labor

W. L. Roller (chairman, subcommittee), E. W. Caruthers, W. E. Cornell, L. W. Deslauriers, J. A. Ellis, J. W. Fulmer, R. A. Gravelle, E. T. Howson, F. J. Jerome, J. H. Kelly, E. E. Martin, J. B. Myers, C. J. Rist, I. H. Schram, G. M. Strachan, Hermann von Schrenk.

Two reports are offered for addition to or replacement of material now in the Manual.

Due to certain changes in practice and the reduction of grades in hickory handles for tools by Division of Simplified Practice, Bureau of Standards, it is considered advisable to revise the Specifications for Hickory Handles in the Manual. In line with this, your committee recommends that the material on the bottom of page 5–49, and on pages 5–50 and 5–51 of the Manual covering Specifications for Hickory Handles for Track Tools, be withdrawn and the specifications revised as shown below, be substituted therefor.

SPECIFICATIONS FOR HICKORY HANDLES FOR TRACK TOOLS

1. Material

Before manufacturing tool handles, producers shall ascertain which of the following kinds of hickory will be accepted. Other woods will not be accepted unless specifically ordered.

Bitternut hickory	Hicoria cordiformis
Mockernut hickory	Hicoria alba
Nutmeg hickory	Hicoria myristicaeformis
Pignut hickory	Hicoria glabra
Shagbark hickory	Hicoria ovata
Shellbark hickory (Bigleaf)	Hicoria laciniosa
Water hickory	Hicoria acquatica

2. Physical Requirements

Except as hereinafter provided, all tool handles shall be seasoned to a moisture content not exceeding 12 percent, and be free from any blemishes or defects that may impair their serviceability, such as decay, cross-grain, dip-grain, holes, large knots, bird peck, splits, heavy stain, warp, light-weight wood, or other injurious characteristics.

Any tool handle may be either all heartwood or all sapwood or a mixture of both.

3. Design

Tool handles shall conform to the design and dimensions shown on AREA Standard Plan 25, which forms a part of these specifications, with an allowable variation of ¼ inch over or under in length and $\frac{1}{16}$ inch over or under in all other dimensions. Eyes and dimensions of such handles are in accord with Simplified Practice Recommendation No.

17—Forged Tools, Bureau of Standards, U. S. Department of Commerce, effective April 1, 1927.

4. Manufacture

Tool handles shall be straight, cut square at the ends, and uniform in size and shape for each type, smoothly finished, and waxed. Lacquered, stained or painted handles are not acceptable.

The manufacturer shall legibly impress into each accepted tool handle, at a location and in a manner that will not weaken the handle, but not closer to the grasp end than 5 inches, whatever grade, maker or ownership symbol may be required by the buyer.

5. Inspection

Handles will be inspected at points of manufacture, shipment, or destination, in suitable and convenient places satisfactory to the buyer.

Inspectors representing the buyer shall have free entry to the works of the manufacturer at all times while work on the contract of the buyer is being performed, and shall have all reasonable facilities (including adequate light) afforded them, free of cost, to satisfy them that the handles being supplied are in accordance with these specifications.

Inspectors will make a reasonably close examination of each handle and acceptance or rejection will be based on visual inspection and the judgment of the Inspector. He will not determine the exact weight and density of each handle, but in case of question, one or both of these characteristics may be accurately measured for conformance with the requirements for each grade. Exactness of size and shape will be checked by accurate measurements of handles taken at random.

Each handle will be judged independently, without regard for the decisions on others in the same lot.

The Inspector shall have his identifying designation legibly branded into the grasp end of each accepted tool handle.

6. Definitions of Blemishes and Defects

light stain. Slight difference in color which does not materially impair the appearance of the handle.

medium stain. Pronounced difference in color which does not obscure the grain of the wood.

medium streak. Discoloration extending more than ⅓ the length of the handle, but not over $\frac{1}{32}$ inch wide.

large streak. Discoloration over $\frac{1}{32}$ inch wide.

knots. Portions of branches incased in trunk of tree.

splits. Lengthwise separations of the wood extending from one surface through the piece to the opposite surface or an adjoining surface.

decay. Deterioration due to the action of fungi.

cross grain. Deviation of the fiber out of parallel with the axis of the handle in excess of 1 in 20.

abrupt dip grain. Deviation of the fiber out of parallel with the axis of the handle in excess of ⅛ the minimum diameter of the handle at the point where the dip grain occurs.

slight dip grain. Deviation of the fiber out of parallel with the axis of the handle not in excess of ⅛ the minimum diameter of the handle at the point where dip (grain) occurs.

holes. Holes (including bird pecks) may extend partially or entirely through the piece and be from any cause.

7. Delivery

Accepted handles shall be shipped by the seller in accordance with the instructions in the order covering them, securely packed in containers marked with the name, type, grade, and quantity of the material therein and with the name of the seller and the number of the buyer, contract or order.

8. Grade Classification

Grade	*Maximum Number of Annual Rings per inch of Radius*	*Minimum Weight per cubic Foot (Pounds)*	*Admissible Blemishes and Defects*	*Maximum Slope of Grain*
A	17	55	Light stain; medium streaks	1 in 50
B-1	22	46	Medium stain; large streak, bird pecks or tight knots not more than ¼ inch in average diameter, in the eye end or first third of the grasp end.	1 in 50
B-2	27	46	Medium stain; large streak, bird pecks or tight knots, the sum of whose average diameters does not exceed ¼ inch, in the eye end or first third of the grasp end; slight dip grain.	1 in 20

9. Use of Classification

Handle	*Grade*	*Minimum Weight per Dozen*	*Number of Tool Plan*
Axe	A	17	--
Adze	A	15	12
Hammer	A	--	--
Hatchet	A	--	--
Pick	A	21	1 & 2
Sledge	A	14	13
Spike Maul	A	15	3
Track Chisel	B-2	7	16 & 17
Track Punch	B-2	7	19
Tie Plug Punch	B-2	7	18
Cant Hook	B-1	--	--
Jack	B-1	--	--

In the Proceedings for 1941, Vol. 42, pages 587 to 594, inclusive, is shown a report on Limits of Wear of Track Tools, which was submitted as a progress report. On the plans in that report are outlined the minimum reclaim limits for each tool to technically fulfill the assignment. It also seemed advisable to recommend certain limitations and

requirements in making the reclamation, but the subject of the assignment omitted any mention of specifications covering reclamation or repairs. The committee therefore offers the following report with the recommendation that it be adopted for publication in the Manual and that the plans of track tools listed therein be revised to show the reclaim limits that were indicated on them in the Proceedings for 1941, Vol. 42, pages 588 to 594, inclusive.

Recommended Minimum Limits for Reclaimed Tools

The limit of wear for each specific tool is indicated by a dashed line and by a note on each plan listed below and as revised to show reclaim limits.

No. 1. Clay pick
2. Tamping pick
3. Spike mauls
5. Lining bar
12. Track adze
12A. Carpenter's adze
13. Double faced sledge
14. Chisel end tamping bar
15. Spear end tamping bar
16. Track chisel, design No. 1
17. Track chisel, design No. 2
18. Tie plug punch
19. Round track punch
21. Track shovel

The committee recommends that the assignment be changed to include the preparation of specifications covering the repair and reclamation of track tools and the study be continued.

Report on Assignment 4 (a)

Plans for Switches, Frogs, Crossings, Spring and Slip Switches Collaborating with Signal Section

E. W. Caruthers (chairman, subcommittee), L. L. Adams, W. H. Bettis, F. J. Bishop, L. H. Bond, C. W. Breed, E. D. Cowlin, H. Q. Day, L. W. Deslauriers, J. A. Ellis, H. F. Fifield, J. W. Fulmer, R. A. Gravelle, H. H. Harman, N. M. Hench, F. W. Hillman, J. V. Houston, A. F. Huber, W. G. Hulbert, C. T. Jackson, A. A. Johnson, L. I. Martin, F. H. Masters, K. R. McLennan, R. E. Miller, J. B. Myers, G. A. Peabody, S. H. Poore, J. A. Reed, O. C. Rehfuss, D. B. Rice, C. J. Rist, I. H. Schram, G. L. Sitton, G. J. Slibeck, C. R. Strattman, H. N. West, R. P. Winton, J. G. Wishart, M. J. T. Zeeman.

The committee has proceeded with the review of all the information in the Portfolio of Trackwork Plans; and the accompanying Conclusions, together with information presented in the Proceedings, Vol. 41, page 565 and Vol. 42, page 595, complete this work.

All details with which the use of signal material is involved have been developed in collaboration with the Signal Section of the AAR. The Standardization committee of the Manganese Track Society has continued its valuable assistance in the preparation of these plans, specifications and supporting data, and also contributed all of the necessary drafting work.

Conclusions

The committee offers for adoption as recommended practice and publication in the Manual the following plans and supporting data:*

Plan No.	*Title*	*Remarks*
Foreword—42	Foreword	Editorial revision of Foreword, dated 1934
SWITCHES		
122–42	11′ 0″ Curved Split Switch with Graduated Risers.	New Plan.
124–42	19′ 6″ Curved Split Switch with Graduated Risers.	New Plan.
126–42	30′ 0″ Curved Split Switch with Graduated Risers.	New Plan.
128–42	39′ 0″ Curved Split Switch with Graduated Risers.	New Plan.
190–42	Diagram Illustrating Preferred Names of Parts for Split Switches.	Supersedes Plans Nos. 190 and 191, revised 1934.
220–42	Manganese Steel Points for Split Switches.	Supersedes Plan No. 220, revised 1934.
BOLTED RIGID FROGS		
390–42	Diagram Illustrating Preferred Names of Parts for Bolted Rigid Frogs.	Supersedes Plan No. 390, revised 1934.
SPRING RAIL FROGS		
407–42	No. 9, No. 11 and No. 12 Spring Rail Frogs.	New Plan.
408–42	No. 9, No. 11 and No. 12 Spring Rail Frogs—Short Spring Rail Type.	New Plan.
490–42	Diagram Illustrating Preferred Names of Parts for Spring Rail Frogs.	Supersedes Plan No. 490, revised 1934.
RAIL BOUND AND SOLID MANGANESE FROGS		
690–42	Diagram Illustrating Preferred Names of Parts for Rail Bound Manganese Steel Frogs.	Supersedes Plan No. 690, revised 1934.
691–42	Diagram Illustrating Preferred Names of Parts for Solid Manganese Steel Frogs.	Supersedes Plan No. 691, revised 1934.
CROSSINGS—DETAILS		
700–B–42	Compromise Joints—Compromise Rails.	Supersedes Plans Nos. 700-B and 700-C, revised 1934.
700–D–42	Crossing Plates.	Supersedes Plan No. 700–D, revised 1934.
CROSSINGS—TIE LAYOUTS FOR		
719–42	Tie Layout for Railroad Crossings.	Supersedes Plans Nos. 719–A, 719–B, 719–C and 719–D, revised 1934.
CROSSINGS—FOUNDATIONS FOR		
721–34	Design of Reinforced Concrete and Pile Crossing Foundations.	Reissue of Plan No. 721, revised 1934.
DOUBLE SLIP SWITCHES AND MOVABLE POINT CROSSINGS		
813–42	No. 8 Double Slip Switch.	New Plan. Supersedes Plan No. 811, adopted 1935.
814–42	No. 10 Double Slip Switch.	New Plan. Supersedes Plan No. 812, adopted 1935.
820–35	Graph Showing Limitations for the use of Crossings with Rigid Center Frogs—Angles up to 15° 30′, inclusive.	Reissue of Plan No. 820, adopted 1935.
821–42	Movable Point Crossings.	Supersedes Plans Nos. 821, 833 and 834, adopted 1935.
835–42	Plates for No. 10 Double Slip Switch.	New Plan. Supersedes Plan No. 831, adopted 1935.
836–42	Fittings for Double Slip Switches and Movable Point Crossings.	New Plan. Supersedes Plan No. 832, adopted 1935.
PERMISSIBLE VARIATIONS IN COMPLETED FROGS AND SWITCHES		
1010–42	Permissible Variations in Completed Frogs	New Plan
1011–42	Permissible Variations in Completed Switches	New Plan

* The plans published during the year, which are now offered for adoption, appear in bulletins as follows:

Bulletin 427 November, 1941	*Bulletin 430 February, 1942*	
122–42	220–42	814–42
124–42	407–42	821–42
126–42	408–42	835–42
128–42	490–42	836–42
190–42	700–B–42	1010–42
390–42	700–D–42	1011–42
690–42	719–42	
691–42	813–42	

SPECIFICATIONS AND DEFINITIONS		
Appendix* "A"–42	Specifications for Special Trackwork.	Supersedes Appendix "A", revised 1934 and portion adopted 1938.
Appendix** "B"–42	Definitions of Terms—Switches, Frogs, Guard Rails, Crossings and Turnouts.	Editorial revision of Appendix "B", revised 1935.

In view of the issuance of the plans listed above, the committee recommends withdrawal of the following plans and supporting data from the portfolio.

Foreword, dated 1934	Foreword.	Superseded by Foreword–42.
190, revised 1934	Diagram Illustrating Preferred Names of Parts for Split Switches with Uniform Risers.	Superseded by Plan No. 190–42.
191, revised 1934	Diagram Illustrating Preferred Names of Parts for Split Switches with Graduated Risers.	Superseded by Plan No. 191–42.
220, revised 1934	Specifications for the Design and Dimensions of Manganese Steel Pointed Switches.	Superseded by Plan No. 220–42.
390, revised 1934	Diagram Illustrating Preferred Names of Parts for Bolted Rigid Frogs.	Superseded by Plan No. 390–42.
490, revised 1934	Diagram Illustrating Preferred Names of Parts for Spring Rail Frogs.	Superseded by Plan No. 490–42.
690, revised 1934	Diagram Illustrating Preferred Names of Parts for Rail Bound Manganese Steel Frogs.	Superseded by Plan No. 690–42.
691, revised 1934	Diagram Illustrating Preferred Names of Parts for Solid Manganese Steel Frogs.	Superseded by Plan No. 691–42.
700–B, revised 1934	Data & Record Sheet for Ordering Compromise Joints.	Superseded by Plan No. 700–B–42.
700–C, revised 1934	Data & Record Sheet for Ordering Compromise Rails.	Superseded by Plan No. 700–B–42.
700–D, revised 1934	Crossing Plate Details including Alternate Styles.	Superseded by Plan No. 700–D–42.
700–E, adopted 1934	Crossing Plate Areas including Explanatory Data	Withdrawn
719–A, revised 1934	Tie Layout for Railroad Crossings Angles 8° 10′ to 14° 15′.	Superseded by Plan No. 719–42.
719–B, revised 1934	Tie Layout for Railroad Crossings Angles 14° 15′ to 25°.	Superseded by Plan No. 719–42.
719–C, revised 1934	Tie Layout for Railroad Crossings Angles 25° to 50°.	Superseded by Plan No. 719–42.
719–D, revised 1934	Tie Layouts for Railroad Crossings Angles 50° to 90°.	Superseded by Plan No. 719–42.
811, adopted 1935	No. 8 Double Slip Switch with Movable Center Points.	Superseded by Plan No. 813–42.
812, adopted 1935	No. 10 Double Slip Switch with Movable Center Points.	Superseded by Plan No. 814–42.
821, adopted 1935	No. 7 Movable Point Crossing.	Superseded by Plan No. 821–42.
831, adopted 1935	Details of Plates for No. 10 Double Slip Switch with Movable Center Points.	Superseded by Plan. No. 835–42.
832, adopted 1935	Details of Fittings for Double Slip Switches and Movable Point Crossings.	Superseded by Plans Nos. 821–42 and 836–42.
833, adopted 1935	Details of Rolled Rail Knuckle Rails and Movable Center Points for Nos. 6, 7, 8 and 10 Double Slip Switches and Movable Point Crossings.	Superseded by Plan No. 821–42.
834, adopted 1935	Details of Solid Manganese Steel and Railbound Knuckle Rails for Nos. 6, 7, 8 and 10 Double Slip Switches and Movable Point Crossings.	Superseded by Plan No. 821–42.
840, adopted 1935	Bills of Material for Nos. 8 and 10 Double Slip Switches and No. 7 Movable Point Crossing in accordance with Plans Nos. 811, 812 and 821.	Superseded by Plans Nos. 813–42, 814–42 and 821–42.
Appendix A, revised 1934 and portion adopted 1938	Specifications for Special Trackwork.	Superseded by Appendix A–42.
Appendix B, revised 1935	Definitions of Terms—Switches, Frogs, Guard Rails, Crossings and Turnouts.	Superseded by Appendix B–42.

* For convenience in printing, Appendix A, which follows, is presented in page form rather than on the sheets of track plan size.

** The revisions made in Appendix B are confined to the substitution of certain definitions appearing in the Glossary of the Manual. Consequently, it is not necessary to present them for adoption.

APPENDIX A

SPECIFICATIONS FOR SPECIAL TRACKWORK

For Rails 90-lb. and Heavier

DIVISION I

GENERAL INSTRUCTIONS

1. The Purchaser will furnish the Manufacturer specifications and drawings, giving rail sections, joint drilling, angles, alinement and general dimensions, and such special details as may be required.

2. Unless otherwise specified, the construction, design and details shall conform to the plans adopted by the American Railway Engineering Association, Construction and Maintenance Section, Association of American Railroads (hereinafter designated AREA) as recommended practice. For track structures for which no such plans have been adopted, the Manufacturer shall, when requested, submit detail drawings for approval.

3. Detail drawings shall be on sheets 22″ wide between outside border lines, with inside border lines ½″ from the top and bottom. The standard length of the sheet shall be 30″ between outside border lines with inside border lines ½″ from the right-hand edge and 1½″ from the left-hand edge. When longer sheets are necessary they shall be in multiples of 6″ and folded back to the standard length. Drawings shall be confined to one subject. The title shall be placed in the lower right-hand corner. The scale of the general drawings shall be 1½ inches equals one foot, where practicable. Details shall be drawn to a scale of not less than 3 inches equaling one foot, where practicable. Dimensions and distances under two feet should be shown in inches; two feet and over, in feet and inches, except that the length of joint bars should be given in inches. Cross-sections shall be section lined for the material to be indicated in accordance with standard sections as shown in the AREA Manual. Manganese steel section to be indicated by heavy single lines.

4. The drawings shall be part of the specifications. Anything that is not shown on the drawings, but which is mentioned in the specifications, or vice versa, or anything not expressly set forth in either, but which is reasonably implied, shall be furnished, the same as if specifically shown and mentioned in both. Should anything be omitted from the drawings or specifications that is necessary for a clear understanding of the work, or should any error appear in either the drawings or specifications affecting the work, the Manufacturer shall notify the Purchaser and shall not proceed with the work until instructed to do so.

DIVISION II

WORKMANSHIP

30. Workmanship

Workmanship shall be first class and in accordance with best current practice. Accuracy of workmanship shall be within the permissible variations prescribed by Plans Basic No. 1010 and 1011.

33. Gages and Flangeways

Permissible variations in manufacture.

(a) All of the following measured on the level of the gage line ⅝″ below tread surfaces.

(b) Track gage may be ⅛″ under or $\frac{1}{16}$″ over the specified gage, for manganese construction, and $\frac{1}{16}$″ under or over for bolted construction, in completed crossing, minimum 4′ 8⅜″.

(c) Guard face gage in completed crossings having a specified track gage of 4′ 8⅝″ or less shall be between 4′ 4⅞″ and 4′ 4$\frac{11}{16}$″, inclusive.

Guard face gage in completed curved crossings having a specified track gage of 4′ 8¾″ or more shall be between—

9′ 1½″ minus specified track gage, and
9′ 1⅜″ minus specified track gage, inclusive.

(d) Flangeways in completed crossings may be $\frac{1}{16}$″ less than the specified width, or more than the specified width if required to conform to (b) and/or (c) above.

(e) Flangeways in completed frogs may vary not more than $\frac{1}{16}$″ ± from the specified width.

(f) Flangeways shall be not less than 1⅞″ deep measured from top of tread surfaces, unless otherwise specified.

(g) Unless otherwise specified, flangeways may be widened, either in design, or as a permissible variation in manufacture, by machining not more than ⅛″ from the side of the guard rail head.

(h) All the above apply to track for steam railroad equipment. Similar variations will be permissible for track for electric railway equipment using smaller wheels.

34. Bending

Bends shall be made accurately in arcs of circles and without injury to the material. It is desired the rails be bent cold. If heating of the rails is resorted to, it must be done in a manner so as not to injure the metal.

35. Planing

All planing must be true and all abutting surfaces must fit accurately.

36. Grinding

Running surfaces of the manganese steel parts shall be ground to as good a surface as that of the rolled rail. Manganese steel portions fitting into rails or other parts shall be ground to a good fit.

37. Drilling and Punching

All holes in carbon steel rails must be drilled. In other parts, all holes for turned pins or bolts and for tight fit of rough bolts must be drilled. Drilling shall be done accurately, on bevel where necessary. Punching will be permitted only in mild steel parts for rivets, loose rough bolts and spikes, except where such holes come so close together or close to the edge of the piece that the metal between holes or between hole and edge is less in width than the thickness of the material, in which case holes must be drilled.

38. Fit of Bolts

Main bolts in bolted frogs and bolted rail crossings shall have a tight fit in straight true holes. Heads and nuts shall have a square bearing. Unless otherwise specified, where bolts do not require a tight fit, drilled or punched holes shall be not more than $\frac{1}{16}$″ and cored holes not more than ⅛″ greater diameter than the bolts. Holes in manganese steel for frogs and crossings may be $\frac{5}{16}$″ greater diameter than the bolts.

39. Rivets

Rivets shall be of full diameter called for on plans and holes for them shall be $\frac{1}{16}$″ greater in diameter. When not otherwise called for by plans or specifications, rivets shall have standard button or cone heads of uniform size for the same size rivet. The heads shall be concentric with the holes. Countersunk rivets shall be flush with the surface and fill the countersink, except that rivets through base plates and tie plates may have a crown of not more than ⅛″ below the lower surface of the plate.

42. Painting

No paint, tar or other covering shall be used unless specified, and shall not be applied before final inspection.

43. Welding

No welding shall be permitted on rails or on surfaces of other parts exposed to wheel wear. Except where welding is shown on plans, it will be permitted in other portions only if in the judgment of the Inspector the strength of the piece is not impaired.

44. Marking

The finished articles shall be plainly stamped with ¾″ figures and letters for identification. The Manufacturer's name or initials, section and weight of rail and month and year of manufacture must be stamped on a rail portion of the structure not exposed to wheel wear and where marking can be plainly seen, or may be stamped on a separate rust-proof plate, secured to the web of the rail, in which case smaller letters may be used. Frogs must be marked with the frog number. All loose parts or fixtures shall be similarly stamped with suitable size letters and figures. On cast parts all or part of the lettering may be cast on the piece.

DIVISION III

MATERIALS

PART 1. INSPECTION, TESTS AND CLAIMS

52. Selection of Material to be Used

The kind of material to be used for the various parts of special trackwork shall be as specified by the Purchaser. If not so specified and two or more kinds are applicable to a particular part, the selection shall be optional with the Manufacturer.

53. Application of Specifications

Any material entering into the manufacture of special trackwork or parts thereof and which is covered by specifications contained (or referred to) herein, shall conform to the requirements of such specifications, unless otherwise specified by Purchaser.

54. Reference to Established Specifications

The specifications contained (or referred to) herein are based as far as possible on established specifications of various national associations with such modified requirements as are necessary to adapt the material to the manufacture of special trackwork.

55. Inspection, Tests and Claims

(a) The records of any tests made by the Manufacturer of materials entering into the work of the Purchaser shall be open, free of charge to the Inspector representing the Purchaser.

(b) The Inspector representing the Purchaser shall have free entry, at all times while work on the contract of the Purchaser is being performed, to all parts of the Manufacturer's works, which concern the manufacture of the materials ordered. The Manufacturer shall afford the Inspector, without charge, all reasonable facilities to examine the work during its progress as well as the finished product to satisfy him that the materials comply with these specifications.

(c) Other chemical and physical tests covered by the specifications shall be made when required by the Purchaser. For materials originally manufactured by the special trackwork Manufacturer for a specific order, such tests shall be made at the expense of the Manufacturer when the amount of the particular kind of material is 50 tons or more; if less than 50 tons the Purchaser shall pay for the expense of such tests, unless the material fails to meet the specifications, in which case the Manufacturer shall bear the expense.

(d) For materials or parts of the work taken from stock or purchased from other manufacturers, the special trackwork Manufacturer, when required, shall certify that the material conforms with these specifications. If the Purchaser desires any chemical or

physical tests of such materials he shall pay the expense of such tests, unless the materials fail to meet the specifications, in which case the special trackwork Manufacturer shall pay the expense. For the rails used in the work the Manufacturer, when requested, shall supply the Purchaser with a certificate of inspection from the rail Manufacturer.

(e) Unless otherwise agreed all inspection and tests shall be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the works or the progress of the work on the Purchaser's order. Chemical and physical tests may be made at a testing laboratory outside of the Manufacturer's works to be agreed upon between the Manufacturer and the Purchaser.

(f) The acceptance of any material by an Inspector shall not prevent subsequent rejection if found defective after delivery.

(g) No guarantee of specific length of service will be required. A claim for defective material and/or workmanship shall cover only such defects as will impair the life of the work.

(h) No claim for free replacement of defective material and/or workmanship shall be recognized unless made promptly and based on defects appearing within three months from date of installation and in any event within two years from date of shipment.

(i) The foregoing paragraphs cover the inspection and tests of the materials when used for special trackwork and take precedence over the inspection clauses contained in the various established specifications for similar materials referred to in Section 54.

DIVISION III

MATERIALS

PART 2. DETAIL MATERIAL SPECIFICATIONS

Article 1. Open-Hearth Steel T-Rails

101. Material Covered

Rails of standard T-rail section 90-lb. per yard and heavier.

102. Manufacture

Unless otherwise specified by the Purchaser, the rails shall be manufactured according to the current AREA Specifications for Open-Hearth Steel Rails of the weight and section specified.

In addition to the requirements of such specifications, the cooling of the rail from the temperature of rolling, shall have been so controlled or manipulated as to minimize the liability of thermal cracks. The particular method of securing this result shall be in accordance with the current AREA recommended practice for controlled cooling of rail, unless otherwise stipulated by the Fabricator and approved by the Purchaser.

103. Quality

No. 1 rails only shall be used in special trackwork, except that the use of No. 2 rails is permitted for guard rails only. All "A" rails are excluded.

Article 2. Open-Hearth Steel Girder Rails of the Plain, Grooved and Guard Types

201. Material Covered

Girder rails of the different types for curves, turnouts and other parts of special trackwork for use in paved streets.

202. Manufacture

Unless otherwise specified by the Purchaser, the rails shall be manufactured according to the current AREA Specifications for Open-Hearth Girder Rails. Where the class of the rail is optional, the special trackwork Manufacturer may use either class.

203. Quality

No. 1 rails only shall be used in special trackwork, except that No. 2 rails may be used for parts of track structures where the necessary machining of the rail entirely removes any flaws or imperfections.

204. Sawing

The ends of the rails shall be sawed at right angles to the gage with a permissible variation of $\frac{1}{16}''$ in 6″ and on an incline from the vertical so that the top edge of the head will project beyond the bottom edge of the base not less than $\frac{1}{32}''$ nor more than $\frac{3}{16}''$. The ends of the rail in special trackwork need not be milled unless specially called for.

Article 3. Rolled Manganese Steel Rails

301. Rolled Manganese Steel Rails

Rolled manganese steel rails shall be in accordance with the rail manufacturer's current approved specifications.

Article 4. Manganese Steel Track Castings

401. Material Covered

Manganese steel castings for solid manganese steel track structures or wearing parts of track structures.

402. Manufacture

(a) The steel shall be made by one or more of the following processes; open-hearth, electric furnace or converter.

(b) The castings shall receive a suitable heat treatment to render them tough and ductile. This heat treatment shall consist of uniformly heating the castings to somewhat above the critical temperature required for carbide solution and a homogeneous austenitic structure [minimum about 1,000° C., (1,832° F.)], holding them at this temperature until they are uniformly heated throughout, and quenching them in water.

403. Chemical Requirements

(a) The steel shall conform to the following requirements as to chemical composition:

	Percent	
	Min.	*Max.*
Carbon	1.00	1.30
Manganese	12.00	....
Silicon	....	2.00
Phosphorus	....	0.10
Sulfur	....	0.05

(b) An analysis of each melt of steel shall be made by the Manufacturer to determine the percentages of the elements specified in paragraph 403 (a). This analysis shall be made from drillings taken at least ¼″ beneath the surface of a test ingot obtained during the pouring of the melt. If requested, the chemical composition thus determined shall be reported to the Purchaser or his representative.

404. Analyses

Analyses may be made by the Purchaser on samples obtained from a casting. The samples for analyses shall be taken not less than ¼″ below the surface in the case of rough castings. In the case of castings finished by grinding or machining, the samples for analysis may be taken at the finished surface, provided at least ¼″ of metal has been removed from the casting at the point selected for sampling. The phosphorus content thus determined shall not exceed 0.11 percent. The carbon thus determined shall not be less than 0.90 percent nor more than 1.50 percent.

405. Physical Requirements and Tests

(a–1) Bend tests shall be required only when specified in the purchase order.

(a–2) When bend tests are specified, the test specimens shall stand being bent cold without breaking, around a pin 1″ diameter to an angle of 150 deg. The bending may be done by any method preferred by the Manufacturer.

(b) In the case of castings weighing not over 50 lb. and if satisfactory to the Manufacturer and Inspector, a test to destruction may be made as an alternative to bend tests when the latter are specified. For this test the castings shall be grouped in lots, each lot containing castings from the same melt and from the same heat-treatment charge. From each such lot the Inspector shall select one casting to represent the lot. The representative casting shall be tested to destruction by pressure or by blows. This test shall show the material to be tough and ductile, and suitable for the purpose intended. The cost of all such test castings shall be provided for in the purchase order.

(c–1) Bend test specimens, when specified, shall not be cast attached to the castings, but shall be poured in separate molds, from the same heat or melt of steel as the castings they represent. They shall be ½″ by ¾″ in cross-section and 12″ in length and shall be heat treated and tested without being machined or ground except when necessary to remove irregularities of surface, or to separate them from the runner or sprue through which they were poured.

(c–2) Bend test specimens, when specified, shall be heat-treated with the castings they represent. When bend test specimens are heat-treated with castings of comparatively heavy section, the test bars should be protected from oxidation by enclosing them in pipes or containers containing a small amount of carbonaceous material, and suitably sealed or luted to prevent the furnace gases from coming in contact with the test bars. To permit the expansion of the gases within these containers, they should not be completely sealed.

(d–1) When bend tests are specified, one such test shall be made from each melt or heat of steel in one heat-treatment charge. When so specified by the Purchaser, one bend test shall be made from the steel used for pouring each casting weighing 500 lb. or over.

(d–2) If any test specimen develops flaws and does not conform to the requirements specified, it shall be discarded, in which case another specimen from the same lot shall be substituted.

(e) If the results of the bend tests for any lot do not conform to the requirements specified, such lot may be reheat-treated, but not more than twice. Retests shall be made as specified in paragraph 405 (a–2). In the case of reheat-treatment and retest, when bend tests are specified in the order, two bend tests from a lot, or from each casting weighing 500 lb. or over, instead of one as specified in paragraph 405 (d–1), shall be required, both of which shall conform to the requirements specified in paragraph 405 (a–2).

406. Bend Test

A bending test demonstration from the test specimen, if specified by the Purchaser, shall be made in the presence of his representative at the foundry where the castings are made.

407. General Conditions

(a) Castings shall be reasonably smooth and true to patterns in accordance with good foundry practice. Large lumps, sharp fins, sand holes and chills on the outside of the casting shall be removed. The casting shall be free from such gas pockets, sand holes, cracks, cold shuts and other defects which would impair their serviceability. Castings must be out of twist and reasonably true, both as to general surface and alinement. and must not show any signs of straining or undue denting produced in the straightening process.

(b) The bottom part of castings which rest on ties shall be reasonably straight and out of twist and shall be free from lumps or such imperfections as would prevent a good bearing.

408. Imperfections

Tread surfaces within 2½″ of gage line and flangeway walls 1″ down from the tread shall be free from physical defects, such as shrinkage, porosity, cracks, sand holes,

gas pockets or cold shuts, unless such defects are so small that they will be practically removed by the finish grinding. Shrinkage cracks, gas pockets or cold shuts will not be allowed in any part of the tread surfaces. Sand holes, gas pockets and cold shuts in portions of the casting where they will not appreciably weaken the casting or impair its wearing qualities will be permitted. Castings must be free from all shrinkage cracks unless they be of such size and in locations which will not affect the service life.

409. Welding

Welding of surface defects by the metallic arc process may be done with the consent and approval of the Purchaser.

Article 5. Carbon Steel Castings

501. Material Covered

(a) Steel castings for general service in trackwork for which no physical nor heat-treatment requirements are specified, except as otherwise provided for in Section 505, including appurtenances and fittings, rail braces, washers, spring housings, separator and end blocks for guard rails, adjusting wedges for guard rail clamps, parts for switch stands, and other parts not exposed to wheel wear, designated as "Grade N–1" castings.

(b) Carbon steel castings for solid cast track structures or parts of track structure exposed to wheel wear for which physical and full annealing requirements are specified, including yokes for guard rail clamps, operating parts for switch stands, special joint bars and blocks in toe or heel joints, designated as "Grade H–1" castings. This grade is designated on some plans as Class "B" Hard.

502. Manufacture

(a) The steel shall be made either by the open-hearth, electric furnace, or converter process.

(b) The castings shall conform in general character to the ASTM specifications A 27–39 for steel castings of "Grade N–1" or "Grade H–1" as designated, and shall comply with the following requirements:

503. Chemical Composition

(a) Grade N–1 Castings

	Percent	
	Min.	*Max.*
Carbon	....	0.45
Manganese	....	1.00
Phosphorus	....	0.05
Sulfur	....	0.06

(b) Grade H–1 Castings

Carbon	0.45	0.55
Manganese	0.60	0.85
Silicon	0.30	0.45
Phosphorus	....	0.05
Sulfur	....	0.06

504. Check Analysis

A chemical analysis may be made by the Purchaser from a broken tension test specimen or from a casting representing each melt. Drillings for analysis shall be taken not less than ¼″ below the surface, and in such manner as not to impair the usefulness of any casting selected for such check analysis. The chemical composition thus determined shall conform to the requirements specified in Section 503 above.

505. Physical Requirements

(a) Grade N–1 Castings. No test for physical properties shall be required unless otherwise specified.

(b) Grade H–1 Castings

Tensile strength	80,000 psi-minimum
Yield point	40,000 psi-minimum
Elongation in 2 in.	17 percent minimum
Reduction of area	25 percent minimum

506. Bend Test

Bend tests shall not be required in either grade of castings.

507. Tension Tests and Alternative Tests

Test on Grade H–1 castings where required, to determine the tensile properties of the castings, or alternative tests therefor, shall be made in accordance with the ASTM Specifications A 27–39.

508. Annealing and Heat Treatment

(a) Grade N–1 castings with carbon content not over 0.30 percent need not be annealed or heat-treated unless so specified. A heat-treatment, either by normalizing or by full annealing at the option of the Manufacturer, shall be applied to all castings of Grade N–1 when their carbon content exceeds 0.30 percent.

(b) Grade H–1 castings shall receive a full-annealing treatment in accordance with the ASTM Specifications, A 27–39, the treatment depending upon the design of the casting.

509. Workmanship

The castings shall conform substantially to the shapes and sizes indicated by the patterns and drawings.

510. Finish

The castings shall be free from injurious defects.

511. Welding

Defects which do not impair the strength or wearing qualities of the castings, except those located on the tread surface within 1½″ of the gage line, may be welded by an approved process. The defects shall be cleaned out to the solid metal, before welding, and when so required by the Inspector, castings shall be submitted to him in this condition for his approval. When required by the Inspector, important castings shall be heat-treated after welding.

Article 6. Gray Iron Castings

601. Material Covered

(a) "General" gray iron castings for switches, fillers, braces, and other general appurtenances for trackwork not requiring high strength.

(b) "High test" gray iron castings for parts of trackwork requiring high strength to sustain weight and shock of car wheel traffic and not requiring to be readily machinable including those generally known as "Semi-Steel" castings.

602. Manufacture

The castings may be made by the cupola or any other approved process.

603. Chemical Composition

(a) For "General" gray iron castings the sulfur content of the metal shall not be over 0.10 percent.

(b) Sulfur determination when required shall be made in accordance with current ASTM Standard Method of Sampling and Chemical Analysis of Pig and Cast Iron, A 48.

(c) For "High Test" gray iron castings no specific chemical composition shall be required.

604. Physical Properties and Tests

(a) For "General" gray iron castings, no test for physical properties shall be required.

(b) "High Test" gray iron castings shall be subject to the following test when required:

(1) Transverse test specimens poured from the same heat as the castings corresponding to ASTM Standard Arbitration Test Bars when placed horizontally upon supports 12″ apart and tested under a centrally applied load shall withstand a minimum load of 3,800 lb. and deflect under this load at least 0.12″ at the center.

(2) The rate of application of the load shall be such that the central deflection of 0.10″ is produced in from 20 to 40 sec.

(3) One test bar representing each set of castings shall conform to the above requirements, otherwise the castings represented by such bars may be rejected.

605. Workmanship and Finish

The castings shall be true to drawing and free from gas holes, cracks, flaws and excessive shrinkage and in all other respects shall conform to whatever points may be specially agreed upon between the Manufacturer and the Purchaser.

Article 7. Malleable Iron Castings

701. Material Covered

Malleable iron castings for fittings and appurtenances for trackwork, braces, washers, switch-clips, spring housings and foot guards.

702. Manufacture

(a) The castings shall be produced by either air furnace, open-hearth, or electric furnace process.

(b) The castings shall be thoroughly annealed. Castings rejected for insufficient annealing may be reannealed once.

(c) When so specified by the Purchaser, the castings shall be manufactured in accordance with ASTM Specifications for Malleable Castings, A 47–33.

703. Physical Properties and Tests

(a) If the Purchaser or his representative so desire, a casting may be tested to destruction. Such casting shall show good, tough malleable iron. No other test shall be required unless otherwise specified.

(b) When so specified by Purchaser the castings shall be subject to the test prescribed by the specifications of the ASTM referred to in paragraph 702 (c) and shall conform to the following minimum requirements as to the tensile properties:

Tensile strength, lb. per sq. in.	50,000
Elongation in 2 in., percent	10
Yield point, lb. per sq. in.	32,500

704. Workmanship and Finish

(a) The castings shall conform substantially to the drawings.

(b) The castings shall be made in a workmanlike manner and shall be free from injurious defects.

Article 8. Steel Forgings

801. Material Covered

(a) Forgings of mild carbon steel, Type A, per ASTM Specifications A 17–29, for corner braces, fillers and other parts of trackwork and track specialties not exposed to wheel wear.

(b) Forgings of high carbon steel, Type A, per ASTM Specifications A 17–29, for riser blocks, switch tongues and other parts of trackwork which are exposed to wheel

wear, also for parts of trackwork and track specialties not exposed to wheel wear, or these forgings may be made from rail steel of the respective qualities specified for open-hearth steel T-rails of standard sections.

802. Manufacture

Forgings shall be manufactured generally in accordance with current ASTM Specifications A 235.

803. Chemical Composition

The steel shall conform to the following requirements as to chemical composition:

	Mild Carbon Steel Percent		*High-Carbon Steel* Percent	
	Min.	*Max.*	*Min.*	*Max.*
Carbon	0.15	0.30	0.30	0.60
Manganese	0.30	0.60	0.60	0.90
Phosphorus	...	0.045	...	0.040
Sulfur	...	0.055	...	0.055

804. Heat Treatment

(a) Forgings of mild carbon steel, shall not be heat-treated unless specified.

(b) Forgings of high-carbon steel, shall be heat-treated by annealing, normalizing, normalizing and tempering, or quenching and tempering as specified, or in accordance with SAE specifications for the type of steel being used and current ASTM Specifications A 235, to obtain the physical properties desired.

805. Tensile Properties

Forgings except when made from rail steel shall conform to the following minimum requirements as to tensile properties:

	Mild Carbon Steel	*High-Carbon Steel*
Tensile Strength, lb. per sq. in.	60,000	80,000
Yield Point, lb. per sq. in.	30,000	40,000
Elongation in 2 in., percent	22	15
Reduction in area, percent	35	30

806. Tests

Tension test shall be made per current ASTM Specifications A 235, when specified.

The test specimen shall be taken from test prolongation or from forgings per current ASTM Specifications A 235.

The test specimen shall conform in dimensions to standard 2″ gage length tension test specimen per current ASTM Specifications A 235.

807. Hardness

(a) Forgings which are exposed to wheel wear in trackwork shall be equal in hardness to rail steel of weight and type of rail with which they are used.

(b) Forgings for trackwork and track specialties where subject to fatigue or where high strength is required shall be of sufficient hardness to minimize wear caused by rotation and/or vibration.

(c) A hardness test shall be made when so specified, the details of which shall be agreed upon between the Purchaser and the Manufacturer.

808. Workmanship and Finish

The forgings shall be free from injurious defects and shall have a workmanlike finish.

Article 9. Rolled Mild Steel

901. Material Covered

Rolled mild steel bars and shapes hammered, pressed or machined for fittings and appurtenances, reinforcements, switch rods, clips, braces, slide and turnout plates, base and special tie plates, hold-down housings, stops, heavy joint bars for the internal joints of solid manganese steel crossings, etc., but not including standard tie plates.

902. Manufacture

(a) When made from bar stock, the same shall be of open-hearth steel conforming in general with ASTM Specifications for Commercial Quality Hot Rolled Bar Steel, A 107–40.

(b) If made from structural steel, rolled shapes or plates, they shall be of Bessemer or open-hearth steel conforming in general with the current AREA Specifications for Structural and Rivet Steel.

903. Chemical Requirements

(a) For bar steel the chemical requirements shall be as follows:

	Percent	
	Min.	*Max.*
Carbon	0.15	0.25
Manganese	0.30	0.60
Phosphorus	...	0.04
Sulphur	...	0.05

(b) For structural shapes and plates the chemical requirements shall be as follows:

	Percent Min.	*Percent Max.*
Carbon	Optional	
Phosphorus—Bessemer	...	0.10
Phosphorus—open hearth or electric furnace	...	0.06
Sulfur	...	0.05
Copper, when specified	0.20	...

904. Physical Requirements

The material for structural shapes and plates, paragraph 903–(b) shall conform to the following requirements as to tensile properties

	Min.	*Max.*
Tensile strength, lb. per sq. in.	60,000	72,000

905. Tests

All tests, when required, shall be made in accordance with the respective specifications referred to in paragraphs 902 (a) and 902 (b).

906. Workmanship and Finish

(a) The permissible variations in the size and dimensions of the rolled bars and shapes shall be within the limits of the specifications referred to in paragraphs 902 (a) and 902 (b).

(b) The finished articles shall be free from injurious defects and accurately machined or otherwise finished for the purposes intended.

Article 10. Rolled Steel Frog Fillers

1001. Material Covered

Rolled steel fillers of various sections to fit T-rails of standard sections.

1002. Manufacture

(a) The steel shall be made either by the Bessemer or open-hearth.

(b) Bars shall be hot rolled.

1003. Chemical Composition

The steel shall conform to current ASTM Specifications A 107 for commercial steel bars of classes applicable hereto.

	Percent	
	Min.	*Max.*
Carbon	0.35	0.55

1004. Workmanship and Finish

The bars shall be smooth, straight and within the following permissible variations and dimensions.

(a) The fishing heights of the fillers shall not vary from that called for by the rail section by more than $\frac{1}{64}''$ over or $\frac{1}{32}''$ less than the nominal dimensions.

(b) Width of fillers between rail webs shall not be more than $\frac{1}{16}''$ over or under the dimensions called for.

(c) Depth of the flangeway groove may be $\frac{1}{16}''$ under or $\frac{1}{8}''$ over dimensions called for.

Article 11. Heat-Treated Rail for Special Trackwork

1101. Material

The rails which are to be heat-treated shall be of No. 1 classification, with "A" rails excluded. Unless otherwise specified by the Purchaser, they shall have been manufactured according to the current AREA Specifications for Open-Hearth Steel Rails.

In addition to the requirements of such specifications, the cooling of the rail from the temperature of rolling, shall have been so controlled or manipulated as to minimize the liability of thermal cracks. The particular method of securing this result shall be in accordance with the current AREA recommended practice for controlled cooling of rail, unless otherwise stipulated by the Fabricator and approved by the Purchaser.

1102. Heat Treatment

The rails shall receive a suitable heat treatment to provide the physical properties specified herein. After this treatment, the rails shall not be heated in excess of 900° F. Bends that cannot be made within this limitation shall be made before heat treatment.

1103. Physical Properties

The rails in completed work shall conform to the following:

	Min.	*Max.*
Brinell hardness number	300	375
Tensile strength, lb. per sq. in.	145,000	...
Yield strength (0.2 percent e), lb. per sq. in.	105,000	...
Elongation in 2 in., percent	10.0	...
Reduction in area, percent	20.0	...

The yield strength shall be determined as described in current ASTM Method E 8, section 26, 2a, for an offset of 0.2 percent.

1104. Test

The test for Brinell hardness shall be made at the center of the top of the rail head. After removal of the decarburized metal to a depth not exceeding $\frac{1}{16}''$, a plane surface shall be prepared as prescribed in current ASTM Specifications E 10, section 5, as follows:

> The surface on which the impression is to be made shall be filed, ground, machined, or polished with emery paper so that the edge of the impression shall be clearly enough defined to permit of the measurement of the diameter within 0.01 mm. (0.0004 inch).

The Inspector representing the Purchaser may make a sufficient number of tests for Brinell hardness to verify the requirement.

The test for tensile strength, yield strength, elongation and reduction of area shall be made upon a standard test piece (current ASTM Method E 8, Fig. 9) prepared from the head portion of the prolongation of one of the rails if the Purchaser specifies this in

advance so that allowance may be made for the necessary material. The test piece shall be machined from the section defined by a 1″ diameter circle scribed tangentially to the top and side of the head. One such test may then be made from each heat-treatment charge. The Fabricator shall assume the expense of the tests when the amount of the heat-treated rail on the order is 10 tons or more; if less than 10 tons, the Purchaser shall pay for such tests, unless the material fails to meet the specifications, in which case the Fabricator shall bear the expense.

If the test piece does not meet the specification, the Fabricator may again heat-treat the rails but not more than three additional times, unless authorized by the Purchaser.

Article 12. Helical Springs

1201. Material Covered

These specifications cover helical springs for spring rail frogs and actuating devices for switches.

1202. Manufacture

The springs shall be manufactured in accordance with ASTM Specifications for Heat-Treated Steel Springs, A 125–39, except for springs less than ½″ diameter when made of pretempered or cold-drawn wire.

1203. Chemical Requirements

The steel for bars ½″ diameter and larger shall conform to the following chemical requirements:

	Percent	
	Min.	*Max.*
Carbon percent	0.90	1.05
Manganese percent	0.25	0.50
Phosphorus	...	0.05
Sulfur	...	0.05
Silicon	0.15	...

The steel for bars less than ½″ diameter may also conform to above requirements unless otherwise specified, or a cold-drawn or pretempered wire meeting ASTM Specifications, A 228–41 and A 229–41, respectively, may be furnished.

1204. Workmanship and Finish

Unless otherwise specified, the tests, permissible variations and finish required by ASTM Specifications A 125–39 shall apply.

Article 13. Joint Bars

1301. Material Covered

(a) Rolled steel joint bars of standard design for joints in rails of standard section or girder rail sections.

(b) Special joint bars including compromise joint bars, when standard rolled sections of joint bars are not applicable.

1302. Manufacture

(a) Joint bars of standard section shall be manufactured according to the current AREA Specifications for Quenched Carbon-Steel Joint Bars.

(b) Special joint bars shall be made of high tensile forging steel or of high tensile cast steel, except that the heavy joint bars for interior joints in solid manganese steel crossings may be of rolled mild steel.

1303. Chemical and Physical Properties

The steel for joint bars shall conform to the specifications contained in section 1302 according to the material that is used.

1304. Tests

Tests, when required, shall be made in accordance with the specifications under which the joint bars are manufactured or in case of special joint bars, according to the test required for the material from which they are made.

Article 14. Bolts and Nuts

1401. Material Covered

Steel bolts and nuts for general use in special trackwork.

1402. Manufacture

(a) The manufacture of the bolts shall conform in general and as far as applicable to current AREA Specifications for Heat-Treated Carbon-Steel and Alloy-Steel Track Bolts, Grade 2.

(b) Bolts and nuts shall conform to the following detail:

Diameters.—(a) Main bolts or bolts through the body and fillers of frogs, guard rails and crossings shall be:

1⅜″ diameter for rails heavier than 110-lb. per yd.

1¼″ diameter for rails 110-lb. per yd. or lighter, down to and including rails having 3″ fishing height.

1⅛″ diameter for rails having less than 3″ fishing height. Fishing height is measured on vertical center line of rail.

(b) Diameter of bolts in joint bars shall be as specified by Purchaser.

(c) Diameter of other bolts shall be as specified on detail plans.

Heads.—American Standard regular square heads (ASA B–18.2–1941) except where otherwise shown on detail plans.

Threads.—American Standard Screw Threads, Coarse Thread Series, ASA B 1.1–1935.

Nuts.—American Standard heavy square nuts (ASA B–18.2–1941) except they shall be ¼″ thicker for main or through bolts.

Fittings.—Bolts shall be equipped as shown on detail plans with head locks, spring washers and flat or beveled washers to provide square bearing and to permit tightening of nuts with a standard wrench.

1403. Physical Requirements

Bolts shall conform to the following minimum requirements as to tensile properties.

Tensile strength, lb. per sq. in.	110,000
Yield point, lb. per sq. in.	80,000
Elongation in 2″, percent	14
Reduction of area, percent	35

1404. Workmanship

(a) Fit of nuts. The nuts shall have a hand-free fit from two to five turns in starting on the bolt and a snug fit for the balance of the screw length.

(b) Unless otherwise specified bolts shall have rolled bodies within the following diameters:

Nominal Inches	*Maximum Inches*	*Minimum Inches*	*Out of Round Inches*
¾	0.758	0.742	0.012
⅞	0.883	0.867	0.012
1	1.009	0.991	0.013
1⅛	1.135	1.115	0.015
1¼	1.261	1.238	0.016
1⅜	1.387	1.363	0.018

(c) When specified bolts shall have turned bodies within the following dimensions:
Maximum diameter = nominal diameter +0.0
Minimum diameter = nominal diameter —0.010

Article 15. Spring Washers

1501. Material Covered

Helical spring washers for use in special trackwork.

1502. Manufacture

Spring washers for all bolts ¾" diameter and over, shall be in accordance with the current AREA Specifications for Spring Washers.

Article 16. Rivets

1601. Material Covered

These specifications cover steel rivets for general use in special trackwork.

1602. Manufacture

The rivets shall conform to the requirements for rivets in the current AREA Specifications for Structural and Rivet Steel. The rivet heads shall conform to the American Standard, Large Rivets, ½ in. Nominal Diameter and Larger, ASA B 18.4–1937. (See AREA Manual, page 15–134).

Report on Assignment 5

Photoelastic Study of Stresses in Tie Plates

A. E. Perlman (chairman, subcommittee), W. S. Boyce, E. W. Caruthers, J. H. Kelly, J. de N. Macomb, G. M. Magee, J. A. Reed.

This is a progress report, embracing information that was developed by means of photoelastic studies and field stress measurements. The field measurements were made in July, 1941, near Price, Utah, by a party under the direction of G. M. Magee, research engineer of the Engineering Division, AAR, and Ray McBrian, engineer of standards and research, of the Denver & Rio Grande Western Railroad. The photoelastic work was done by Walter Leaf, research technician in the laboratory of the D. & R. G. W. at Denver.

These two types of studies show that the amount and distribution of stress in a tie plate is materially influenced by the following factors:

1. Fit between rail base and plate.
2. Fit between plate and tie.
3. Design of rail base.
4. Design of tie plate.
5. Elastic modulus and uniformity of tie.
6. Direction and amount of applied load.

Direct compression and shear in a plate supported uniformly by a perfectly rigid tie would be very low and would be a simple function of bearing area between rail and plate and the applied load. As in the majority of stress studies, a bending moment and

consequently deflection of the piece under consideration are the cause of high stress. Consequently, a consideration of the influence of the six listed factors on the bending moment in the plate will lead to a better understanding of tie plate stress.

These factors are so closely related that it is difficult to consider them separately. Lumped together, they control the distorted shape that the plate assumes under the load. and consequently the stress in the plate. Obviously, the fit between rail and plate may change under variations of load, as may the fit between plate and tie. Again, the fits are influenced by all of the other listed factors.

The Photoelastic Method

The photoelastic method of study has the advantage that all factors may be closely controlled so that the influence of each one may be studied separately. It has the further advantage that the entire stress condition can be noted almost at a glance. The field method with strain gages has the disadvantage that only isolated points may be studied, and it is never known whether the region of maximum stress was covered. It has the obvious advantage, however, of measuring directly the actual stress in the actual piece at the gage location. A combination of the two techniques, therefore, will give the maximum possible information.

Fig. 1 presents data obtained by photoelastic methods wherein the several conditions thought possible were studied one at a time. Considering them in order as they are numbered on the graph, curve No. 1 is the stress distribution in a model resting on the lower ribs, with contact between rail and plate at the outer ½ in. of the rail base.

These graphs are for the D. & R. G. W. double-shoulder 112-lb. tie plate. It is $\frac{23}{32}$ in. thick under the outer edge of the base of rail, $\frac{19}{32}$ in. thick under the inner edge, has two bottom ribs near the rail edge, and is 8 by 11½ in. in size. It has been considered that any cross section of plate perpendicular to the rail axis would have the same stress distribution as any other such section. This would not be true of a plate with longitudinal camber.

The figures for stress concentration factor along the side of the graph show the ratio between stress in the plate and applied load, and the graph shows tension along the bottom of the plate. In general, the compression along the upper part of the plate is equal numerically to the tension along the bottom.

Curve No. 2.—This shows the stress distribution in the model resting on a tie model made of paper pulp. The elastic modulus of the tie model is such that it represents a tie with a modulus of elasticity of 850,000 psi. The plate is seated on the tie. Note that the maximum stress concentration factor is 0.25. With the plate seated on a tie model of proper modulus to represent a tie of around 40,000 psi., this factor is increased to 0.40; but the shape of the curve remains practically unaltered. In this case there is a uniform contact between the rail and plate. The factor of 0.40 predicts a maximum stress of 14,000 psi. in the plate, with full 36,000-lb. tie reaction.

Curve No. 3.—Edge contact between rail and plate, with plate on a paper pulp tie. On gasket rubber, the factor increases from 0.25 as shown, to 0.30.

Curve No. 4.—Plate seated on a paper pulp tie, with ½-in. central contact between rail and plate. Maximum factor 0.69. On gasket rubber the factor increases to 1.25. This condition would not be met in actual service, since the contact area between a badly crowned rail and a plate would be several inches wide at the least.

Curve No. 5.—Tie plate resting on ribs, with flat contact areas between rail and plate. The maximum factor is 0.72. The theoretical value for a uniformly applied load is 1.10. The difference between the two figures is caused by the difference in deflections of the plate and rail base. The plate deflects more than the base of the rail, throwing

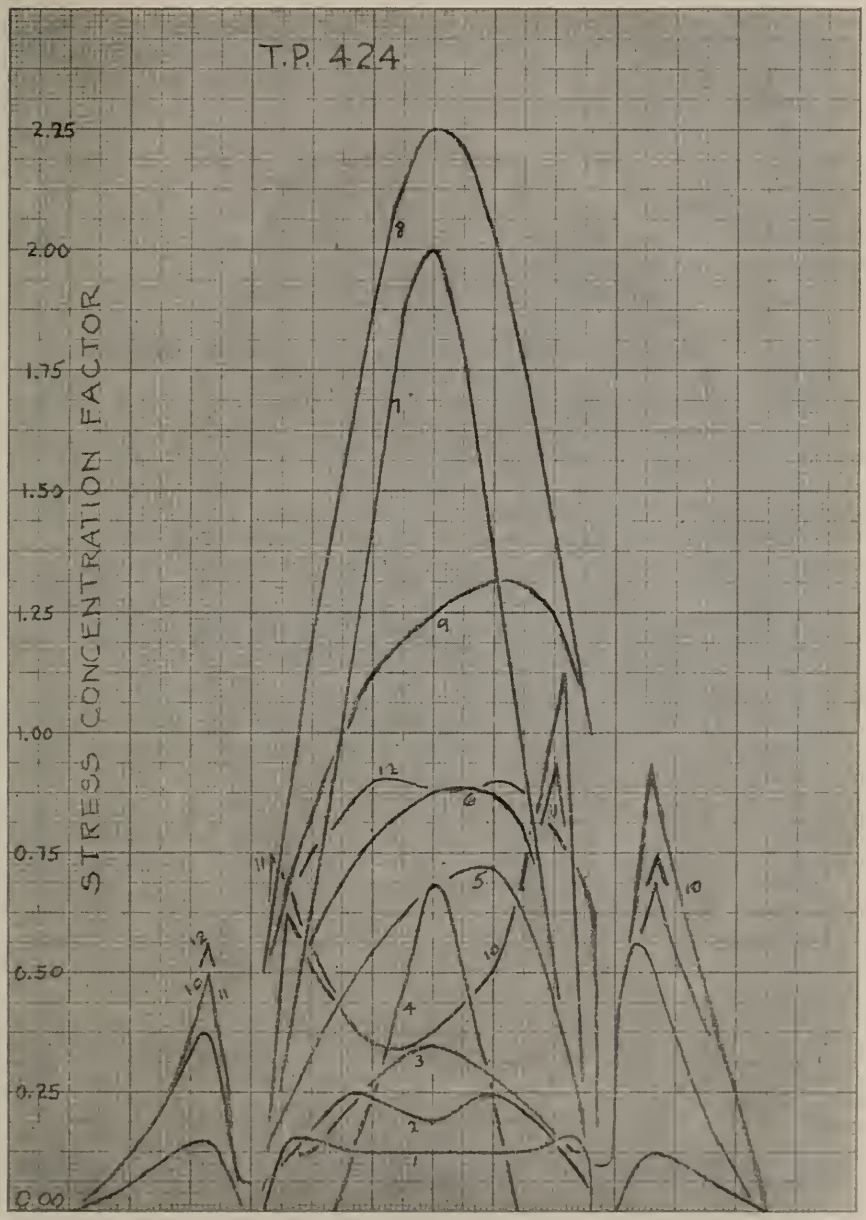


Fig. 1.—Stress Distribution Diagrams in Tie Plate Under Various Conditions of Loading and Support.

more reaction to the outside, thus decreasing the bending moment. When a piece of sponge rubber was put between the rail and plate models so that uniform loading was approximated, the observed factor was 1.09.

Curve No. 6.—Tie plate resting on ribs, but with a four-inch central contact between rail and plate, instead of a full contact as in No. 5.

Curve No. 7.—Tie plate resting on ribs, ½-in. central contact between plate and rail. This condition would not be met in service. The theoretical value for concentrated load at the center is 2.20.

Curve No. 8.—Tie plate seated on thick sponge rubber so that the reaction between plate and tie is uniform across the entire width. A ½-in. central contact between plate and rail. This condition would not be met in service.

Curve No. 9.—Plate seated on thick sponge rubber, with a four-inch central contact between plate and rail.

Curves No. 10 and 11.—The central portion of No. 11 has not been drawn since it coincides with No. 10 over that range. No. 10 is the observed stress distribution with the plate seated on thick sponge rubber, with contact at the edge of rail base and plate. No. 11 is a calculated stress distribution, assuming edge contact between rail and plate, and a uniform reaction between tie and plate.

Curve No. 12.—Plate seated on sponge rubber tie with uniform contact between plate and rail. Contrast this with No. 2, where the plate rests on a tie of much higher elastic modulus. The two curves are of the same shape, but of much different values, showing that the stress in the tie plate is materially influenced by the elastic modulus of the tie.

These curves show the variety of stress distribution that may be encountered in tie plates.

Field Stress Measurements

Field stress measurements on a tie plate were made by the AAR test party in July, 1941, near Price, Utah. The data obtained have been analyzed and supplemented with further photoelastic data for this report. The field measurements were made by fastening five strain gages to the under side of a D. & R. G. W. double shouldered tie plate. The location of these gages is indicated on the graphs by the points labeled "Field Measurements". The gages were at points directly below the circled stress values.

The tie plate used for this investigation was $\frac{23}{32}$ in. thick under the outer edge of the rail base and $\frac{19}{32}$ in. thick under the inner edge. It was 11½ in. long and 8 in. wide. The plate extends 3¼ in. outside of the rail and 2¾ in. inside the rail. The plate was new, and the contact surface for the rail was evidently slightly dished, since what abrasion was noted was mainly toward the outer edges.

The gages were placed along the transverse center line of the plate, and a channel about 1 in. wide and ¾ in. deep was cut in the tie to allow space for the gages and lead wires. The tie was cedar, in good condition, and showed evidence that the plate was fully seated on it; however, it was not excessively abraided, or cut at the ends of the plate.

The bearing between plate and rail was controlled during several of the runs, by inserting shims of metal about $\frac{1}{32}$ in. thick between the plate and the rail base. Thus, on one run, shims ½ in. wide were placed along each edge of the rail base; and on another they were placed side by side along the center of the rail.

After the field data were obtained, it was desired to know the entire stress distribution along the plate. The field measurements merely gave readings at five isolated points, and it was not known whether the gages had been placed at locations of maximum stress.

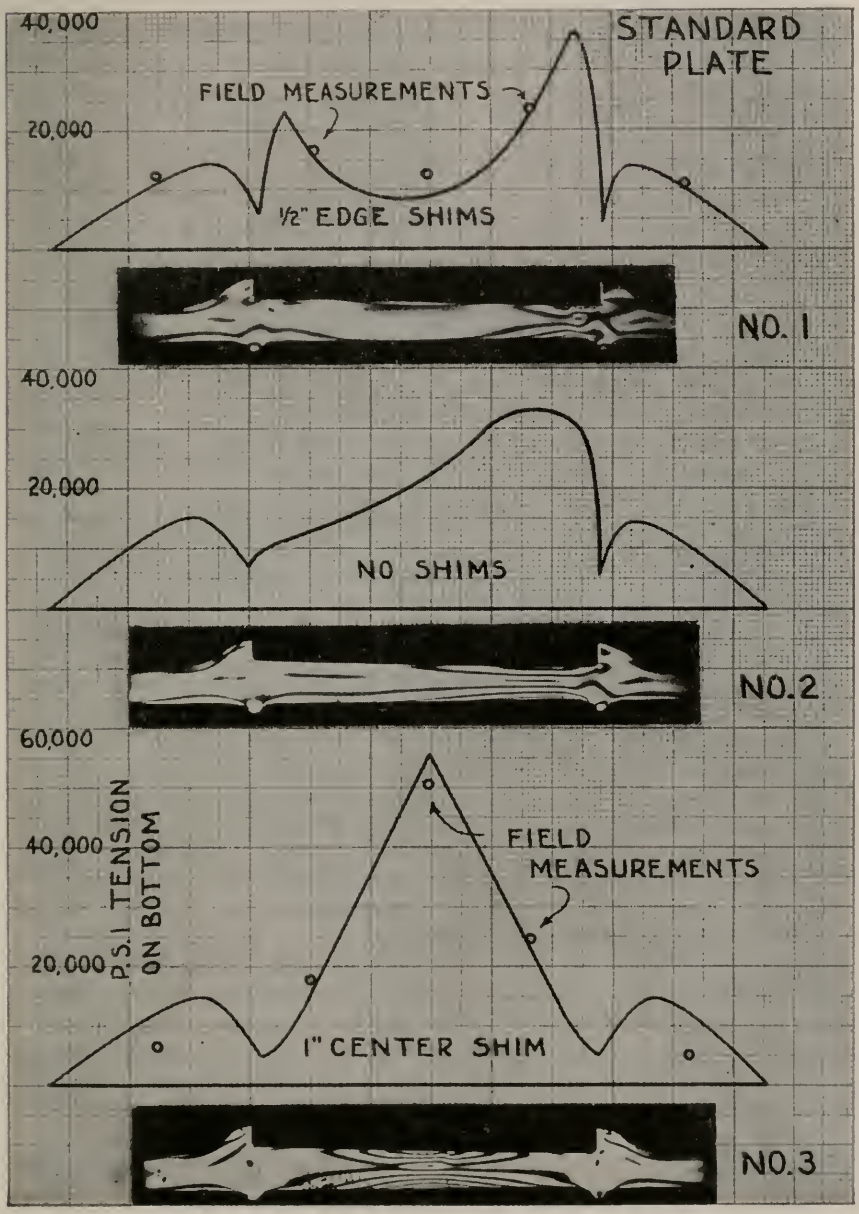


Fig. 2.—Stress Diagrams for Various Types of Loading of Standard Double-Shoulder Tie Plate, and Data from Photoelastic and Field Strain Gage Measurements.

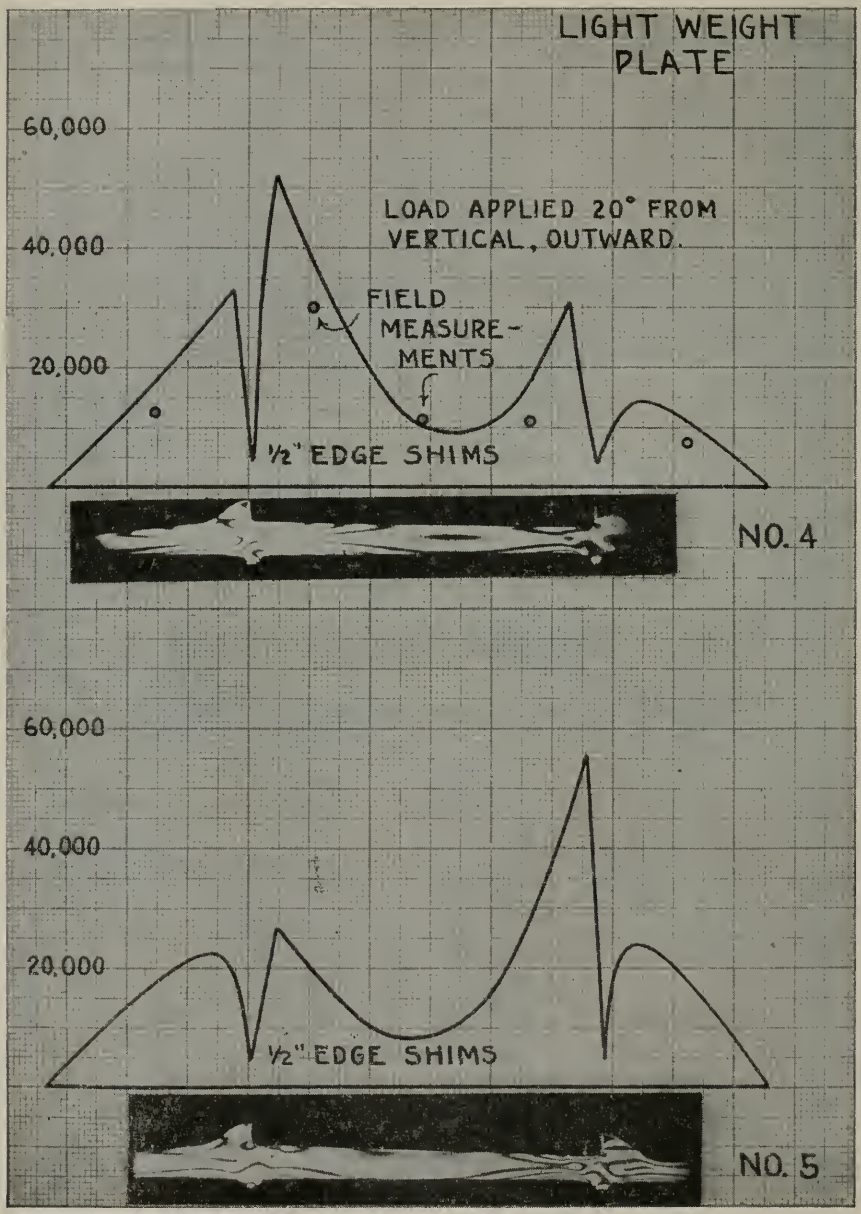


Fig. 3.—Predicted Stress Diagrams for Special Light-Weight Tie Plate Under Various Types of Loading.

Discussion of Photoelastic Studies

To obtain the entire stress pattern, photoelastic methods were used. A cross sectional model of the plate was made to ½ scale. A great deal of investigation was made on the problem of a suitable material for the tie model. The plate model is made from a material having about 1/60 the elastic modulus of steel. The elastic modulus of the actual tie was assumed to be of the order of 35,000 psi., hence the tie model should have a modulus of about 600. No material with this characteristic was available, but rubber ¼ in. thick and having a modulus of 125 psi. was on hand. Hence it was used; but the depth of the "tie" was only 1 in., thus having the elastic properties of a full scale tie model with a modulus of 500 psi., or representing a tie with a modulus of 30,000 psi.

The model was loaded with a one (prototype) in. shim between plate and rail until the number of photoelastic bands in the center section was 1/1000 of the maximum stress measured in the field at these locations, and the pattern photographed. The same value of loading was also used with edge shims between plate and rail and with no shims.

Graph No. 1, Fig. 2, gives the stress distribution along the bottom of the plate as determined by the photoelastic methods outlined. The maximum measured values for the five locations of gages are indicated by the circles.

The agreement between photoelastic and field measurements is very good except at the center point. The reason for this disagreement probably lies in the elastic modulus of the tie model, or some other such variable as seating of the actual plate on the actual tie.

The graph from photoelastic methods shows that gages were not located at points of maximum stress. The maximum observed value was 23,500 psi. and the graph indicates a maximum of 36,000 psi. a little to the right of the gage location.

Graph No. 2 shows a stress diagram obtained from the outlined photoelastic method without shims between plate and rail models. The unusual shape of this graph probably is due to uneven contact surface between the models.

Graph No. 3 gives the stress diagram for loading with central shims, and the maximum observed field data for that condition. Again the agreement is good. The differences at the center are partly due to the fact that field measurements give the average stress over the ½-in. gage length, rather than the maximum within that length. At the outside points, disagreement is probably caused by errors in the elastic modulus of the tie model as previously mentioned, and lack of perfect seating of the actual plate. Wood is not a homogeneous material as is rubber. It has fibrous streaks of harder material through it. Also, under the ribs, there is a layer of crushed fiber which probably has a different elastic modulus than the average.

A model of a plate ⅛ in. thinner than the standard was made and loaded to the same value as used in the other 3 cases. The stress diagrams from this model are shown in graphs 4 to 7, Figs. 3 and 4.

Graph No. 4 gives the stress distribution where edge shims are used. The direction of applied load in this case was 20 deg. outward from the vertical instead of vertical as in all other cases. A set of field measurements is put on this graph. This set was chosen because it follows the general type of stress distribution shown by the graph. Compare this graph with the one immediately below, which is from vertical loading with edge shims. These two show that the stress values and distribution depend on the direction of the applied load.

Graphs 6 and 7 show other stress distributions obtained with conditions as indicated. Compare Nos. 7 and 3, for the same type of loading, but with different thicknesses of plates.

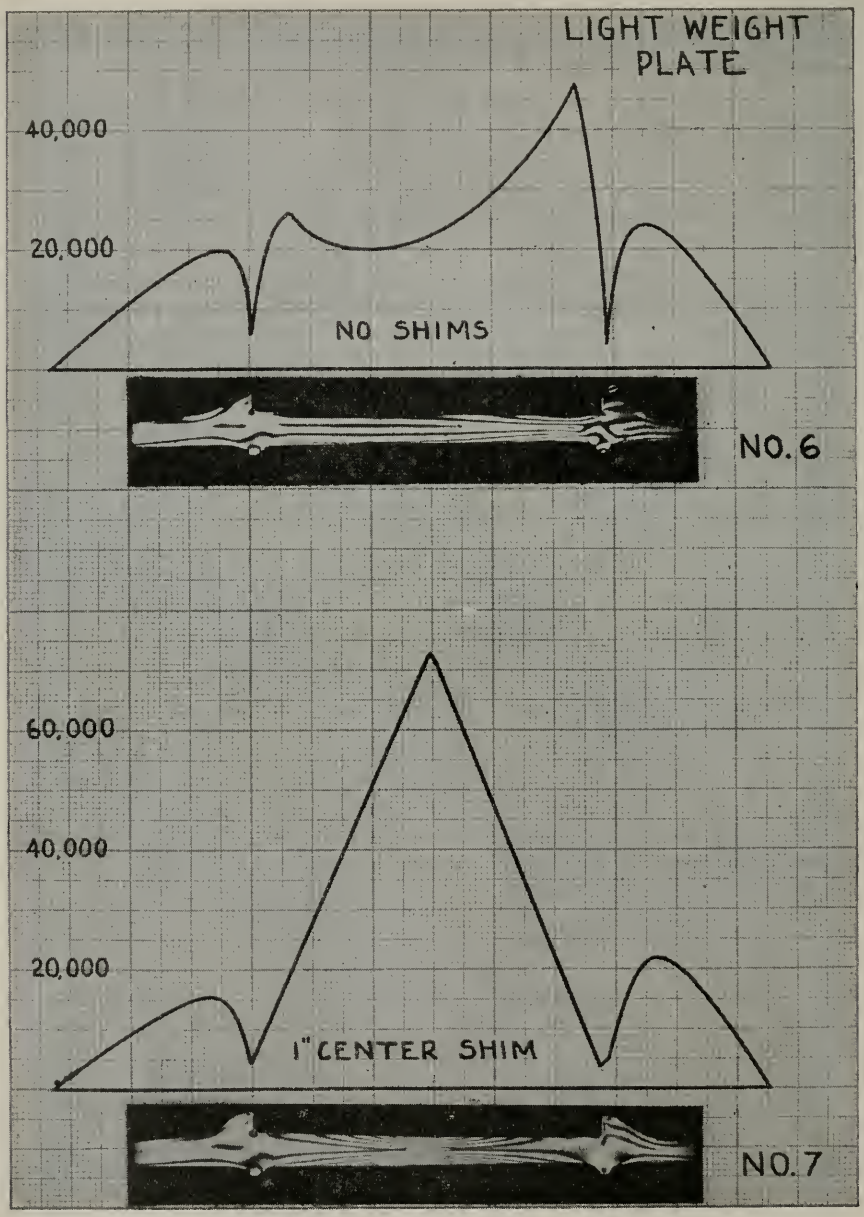


Fig. 4.—Predicted Stress Diagrams for Special Light-Weight Tie Plate Under Various Types of Loading.

The maximum value shown in No. 3 is 55,500 psi. and in No. 7 it is 73,000 psi. At the center of the plate, the section modulus of the standard plate is 0.575. For the light weight plate, the value is 0.377. If the stress at the center of the plate were strictly a function of load and section modulus, a load which gives 55,500 psi. in the standard plate would produce 84,600 in the light weight plate. The actual value of 73,000 is 12.5 percent low, which is considerably more than the expected error of the method. Consequently stress in a tie plate is not merely a function of applied load and thickness of plate. This point was brought out in a previous report where various thicknesses of rectangular bars were supported on rubber "ties" and loaded at their central points. The thinner bar deflects more under a given load than the thicker one, thus removing a greater proportion of its length from tie reaction, and consequently behaving as though supported on a shorter span.

A number of field determinations are yet to be made. Due to the time factor, the measurements were rather limited. The test party chose the firmest tie to be found at the test site, yet may not have found the location that gave the greatest tie plate stress. Consequently an investigation along the track should be made to determine the effect of both "soft" ties and "firm" ties under high speed wheel impacts, joints, and trains at various speeds.

The effect of curvature and direction of applied load should also be studied. Although the field work to date has been rather brief, it has indicated, together with the photoelastic work, that the D. & R. G. W. tie plate weighing about 15 lb. is heavier than need be.

Report on Assignment 6

Design of Tie Plates for RE Rail Sections as Developed

Collaborating with Committees 3—Ties, and 4—Rail

J. de N. Macomb (chairman, subcommittee), L. L. Adams, W. S. Boyce, E. W. Caruthers, H. R. Clarke, O. U. Cook, J. A. Ellis, H. F. Fifield, C. T. Jackson, J. A. Reed, G. L. Sitton, G. M. Strachan.

Your committee offers the following statement of progress:

The Manual contains plans for the following tie plates with inclined ends:

For use with 112-lb. RE rail—11 in. long
For use with 131-lb. RE rail—12 in. long

In response to the demand for larger tie plates with inclined ends, a canvass of the principal railroads was made under date of May 19, 1941. This canvass indicates that 14 railroads favor the preparation of plans for tie plates larger than those referred to above, and that

a 12-in. section for use with 112-lb. RE rail, and
a 14-in. section for use with 131-lb. RE rail

would most nearly meet the requirements of the railroads concerned.

Report on Assignment 7

Practicability of Using "Reflex" Units for Switch Lamps and Targets

Collaborating with Committee 10—Signals and Interlocking

L. L. Adams (chairman, subcommittee), F. J. Bishop, H. R. Clarke, I. H. Schram, J. F. Shaffer, G. L. Sitton, M. J. T. Zeeman.

Your committee offers the following report as information.

The first report on this assignment was made in 1933, and at that time three railroads were reported as having appreciable numbers of units in service and appeared definitely committed to their use. By 1939 the number of railroads using them had increased to 13, and they reported 4,588 units in service. The 1941 report showed nine states as having laws which prohibited the use of reflex units. However, one of these states, Colorado, now permits the use of reflex lenses for switch lamps and targets.

This year a questionnaire pertaining to reflex units was mailed to 78 roads; and of the 46 roads answering the questionnaire, 1 states that it will not use reflex units, 2 state that tests were unsatisfactory, 1 reports the installation was so recent that no report can be made, and 17 have no installations. Twenty-five roads, representing a total of 98,353 miles, show the following:

	Reflex Units
Button type in panels to replace lenses in switch lamps	13
Four button type panels built into a unit to replace switch lamps	2,277
Four reflex lenses mounted in housing to replace switch lamps	2,943
Two red reflex lenses mounted back to back, to replace switch lamps	1,675
Reflex lenses used to replace lenses in switch lamps	3,846
Total	10,754

The order of preference is:

First; four reflex lenses mounted in housing, to replace the switch lamp.

Second; reflex lenses used to replace lenses in the switch lamp.

The button type is preferable at locations where vandalism results in the breakage of lenses.

The use of the reflex units on 21 roads has passed the experimental stage.

Reports received give the following annual costs:

	Average	*Minimum*	*Maximum*
Oil lighted switch lamps	$17.63	$9.00	$30.00
Electric lighted switch lamps	10.22	4.00	17.28
Reflex units	3.01	1.00	10.32

With the exception of two roads reporting, all retain the switch target for day indication.

Only two roads favor the outlining of switch targets by means of reflector buttons

Only two roads replying report trouble on account of snow and ice, and one of these has a total of 1,945 units on a territory of 9,880 miles. Only one road has found it necessary to discontinue the use of the units on this account.

Ten reporting roads have found reflex units objectionable due to the fact that conductors cannot tell when trainmen have thrown a switch to the main track, but only

one road has discontinued their use on this account. This objection can be overcome if trainmen will hold a light in front of the unit after closing the switch.

It has not been found that there is any greater decrease in efficiency of reflex units on account of adjacent illumination than with oil or electric switch lamps.

Other objections to the use of reflex units not referred to above are as follows:

They are not visible from a train running without head lights.

Proper sight distance cannot be obtained on curves or at summits. This is true of lamps.

Not satisfactory for back-up movements.

Not practicable on yard leads or where considerable night switching is done.

Reports received indicate that reflex units are generally practical at the following locations:

Main line switches in automatic signal territory not located at signal.

Main line switches outside of automatic signal territory.

Switches leading from passing tracks, or other side track switches where cars are not handled ahead of engines, nor engines operated in back-up movements.

Derails where lights are maintained.

Fixed caution signals and slow order signals.

Reports generally indicate that reflex units are distinguishable as to color for distances at least as great as oil lamps.

Tests have shown that they give indications on curves at as great a distance as oil lamps.

Conclusions

The number of reflex units in service indicates that they are safe and satisfactory.

The estimated annual average saving of over $157,000 made by 10,750 units already in service indicates the potential savings.

Report on Assignment 8

Welding of Manganese Castings in Special Trackwork

Collaborating with Committee 27—Maintenance of Way Work Equipment

F. J. Bishop (chairman, subcommittee), Lem Adams, A. L. Bartlett, W. H. Bettis, E. W. Caruthers, H. Q. Day, H. H. Harman, F. W. Hillman, W. G. Hulbert, C. T. Jackson, F. J. Jerome, G. M. Magee, L. I. Martin, F. H. Masters, K. R. McLennan, R. E. Miller, G. A. Peabody, O. C. Rehfuss, D. B. Rice, G. L. Sitton, G. J. Slibeck, H. N. West, R. P. Winton, M. J. T. Zeeman.

Two previous reports on this subject have been made to the Association. The first report, in the Proceedings for 1938, Vol. 39, pages 416–419, inclusive, gives general information on manganese steel, the technique to be followed in welding manganese castings, and a general recommendation for successful repairs by welding, based on information available at that time. In 1940 it was decided to undertake a research program to improve the technique of manganese welding and determine the relative

merits of available welding rods. The scope of the program and a description of the installation of test frogs on the Chicago, Milwaukee, St. Paul & Pacific Railroad was published in the Proceedings for 1940, Vol. 41, pages 573–574.

These 24 test frogs have now been in service since November 1939. Periodic batter tests and surface hardness values are being taken. The laboratory facilities of the Milwaukee have been made available to the committee. Supplementary to the field tests, laboratory work is being performed both on test bars and on sections of worn welded turnout frogs that have carried very heavy traffic. Welding of these test frogs will be started as soon as the wear progresses to the point at which maintenance welds would normally be made. The committee anticipates that some welds can be started in the spring, others later, depending on the rate of wear.

The committee recommends that the subject be continued.

Report on Assignment 9

Bolt Tension Necessary for Proper Supporting of Rail Joints

C. W. Breed (chairman, subcommittee), C. W. Baldridge, A. L. Bartlett, W. S. Boyce, W. E. Cornell, E. D. Cowlin, L. W. Deslauriers, H. F. Fifield, J. W. Fulmer, C. T. Jackson, J. de N. Macomb, G. M. Magee, E. E. Martin, S. H. Poore, G. M. Strachan.

Your committee submits as information the following report of progress in the tension tests of bolts installed in the tracks of several railroads, as described in the Proceedings, Vol. 40, page 565; Vol. 41, page 574; and Vol. 42, page 608.

Chicago, Milwaukee, St. Paul & Pacific

The test installation on the Milwaukee Railroad near Winona, Minn., was described in the AREA Proceedings, Vol. 40, page 570. The rail is 112-lb. with 6-hole toeless joint bars and 1-in. diameter track bolts with no spring washers.

Loss of Bolt Tension Under Traffic

The test bolts were retightened June 12, 1940, by hand wrenching. The track man tightened a few bolts and the bolt tension was measured until he knew just about how much pull to exert on the wrench to obtain the desired tension. He then tightened all test bolts out-of-face and generally it was found that the bolt tension applied was reasonably close to the desired amount when the measurements were made. It was necessary on a few bolts to readjust the tension he applied because it was found to be either too far above or below the desired amount. As in previous years, a range of applied bolt tension of from 8,000 to 12,000 lb. on the north rail and 15,000 to 20,000 lb. on the south rail was the aim.

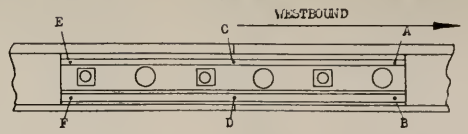
The bolts were left undisturbed until June 27, 1941, when the remaining bolt tension was measured. A few bolts had become loose in the meantime and were tightened by the section forces. These were reported as zero remaining tension. Table 1 gives the average bolt tension per joint as applied and as remaining. It will be noted that a considerable loss of tension occurred during this year's period, being somewhat greater than occurred in the preceding year's test period. The number of bolts which became loose during this year's period, or were found to be loose on June 27, 1941, were as follows: north rail—30, or 15 percent; south rail—11, or 6 percent. The test bolts were retightened on June 27 to continue the observations.

Table 1
BOLT TENSION MEASUREMENTS
C M St.P & P RR Test Installation

	NORTH RAIL			SOUTH RAIL		
	Average Bolt Tension Per Joint - Lb.			Average Bolt Tension Per Joint - Lb.		
Jt. No.	Applied 6-12-40	Remaining 6-27-41	Lose	Applied 6-12-40	Remaining 6-27-41	Lose
1	11,100	3,200	7,900	22,800	6,800	16,000
2	12,100	3,300	8,800	21,000	5,100	15,900
3	10,600	4,100	6,500	23,200	8,200	15,000
4	13,600	3,600	10,000	17,100	4,300	12,800
5	16,800	7,000	9,800	23,400	13,200	10,200
6	10,500	4,000	6,500	26,800	11,600	15,200
7	10,500	5,100	5,400	-	-	- *
8	9,500	4,900	4,600	18,400	9,300	9,100
9	9,800	4,600	5,200	19,400	8,500	10,900
10	11,600	5,000	6,600	16,700	8,500	8,200
11	10,700	1,800	8,900	19,400	5,000	14,400
12	9,700	3,500	6,200	15,900	5,400	10,500
13	9,100	4,300	4,800	16,300	4,700	11,600
14	7,400	800	6,600	21,200	7,200	14,000
15	8,400	4,000	4,400	18,400	4,600	13,800
16	11,100	3,500	7,600	19,100	6,300	12,800
17	8,900	2,800	6,100	19,400	7,200	12,200
18	9,900	2,600	7,300	20,500	8,500	12,000
19	10,800	3,700	7,100	22,300	8,000	13,500
20	10,300	4,300	6,000	20,200	7,400	12,800
21	11,700	2,200	9,500	19,000	6,800	12,200
22	9,100	4,900	4,200	18,400	5,600	12,800
23	8,300	4,700	3,600	17,500	5,900	11,600
24	9,900	5,300	4,600	18,400	8,500	9,900
25	7,800	5,700	2,100	18,000	8,100	9,900
26	9,800	4,300	5,500	18,400	5,700	12,700
27	11,600	5,800	5,800	19,000	5,300	13,700
28	11,100	3,200	7,900	21,700	7,600	14,100
29	8,500	4,500	4,000	20,700	7,400	13,300
30	11,600	4,900	6,700	19,800	9,800	10,000
31	10,800	5,500	5,300	21,800	9,000	12,800
32	9,800	6,000	3,800	17,100	8,000	9,100
33	11,700	3,600	8,100	22,300	7,600	14,700
34				21,300	8,900	12,400
Ave.	10,400	4,100	6,300	19,800	7,400	12,400
% Loss of Original Tension			60.5%			62.6%

* Crossing Plank.
Note: Compare with Vol. 41, page 582
" " Vol. 42, page 608

Table 2



Average Change in Out-to-Out Distance of Joint Bars

C M St.P & P Test Installation

(From 12-2-38 to 6-27-41)

Location	NORTH RAIL Average Change Inches	SOUTH RAIL Average Change Inches
A	.034	.042
B	.042	.038
C	.029	.040
D	.035	.039
E	.026	.026
F	.031	.018
Average	.033	.034

Note: The average change is a decrease in out-to-out measurements at the locations shown.

Compare with Vol. 42, page 609.

Out-to-Out Measurements of Joint Bars

As described in last year's report, measurements have been made with the joint bar caliper of the out-to-out distances between the two bars of each joint on both top and bottom ribs at each end and at the middle. The change in this out-to-out distance from year to year represents wear of the fishing surfaces of rail and joint bars and corresponding take-up of the clearance provided between the bar and the rail web. The average change in out-to-out distance for the test joints from December 2, 1938, to June 27, 1941, is shown in Table 2.

The most significant fact to be noted from these measurements is that there has been practically the same amount of wear at the joints on both north and south rails, notwithstanding the fact that the bolts have been maintained at approximately twice as much tension on the south rail as on the north rail.

Chicago, Burlington & Quincy

The bolt tension test installation on the Burlington near Western Springs, Ill., was described in the report of 1939 (Vol. 40, page 568). The test includes approximately 40 joints on the north rail and 40 joints on the south rail on the eastbound main track between Western Springs and Highlands. The rail in the test is 131-lb. with 6-hole toeless joint bars of both headfree and head contact types, 1-in. heat treated track bolts, and "Triflex" springs or "double-coil improved Hipower" spring washers. The rail was laid new and the test started in August, 1938.

There are four different test sections on both north and south rails of approximately 10 joints each, in the following order from west to east:

Headfree bars with "Hipower" spring washers.
Headfree bars with "Triflex" springs.
Head contact bars with "Hipower" spring washers.
Head contact bars with "Triflex" springs.

Loss of Bolt Tension Under Traffic

In Fig. 1, the average bolt tensions for the various dates of measurements are given for each separate test section on the north rail, and corresponding data in Fig. 2 for the south rail. Much higher bolt tension has been maintained for the north rail than for the south rail. These figures are of interest in showing the trend of bolt tension loss under traffic. It will be noted that the rate of loss has been much less after the retightening on April 25, 1940, than after the tightening on October 5, 1938. During the period after April 25, 1940, the head contact bars have shown a relatively greater loss of bolt tension than the headfree bars, although in the preceding period this was not evident.

The loss of bolt tension for each test section in this latter period and average loss per month are given in Table 3 (compare with Table, page 612, AREA Proceedings, Vol. 42). It will be noted that the average loss in bolt tension per month was considerably greater during this period for the head contact type bars than for the headfree bars. The reason for this is shown by the out-to-out measurements discussed below.

Further mention of the comparative loss in bolt tension with Triflex springs and double-coil Hipower spring washers will be made under the discussion on Reactive Properties of Spring Washers. It should be observed, however, that irrespective of type of bar or spring washer used, there is a definite relation between the initial bolt tension applied and the number of bolts found loose at the end of the 18-month test period. On the north rail with an average initial tension of approximately 30,000 lb., there were only two loose bolts and one of these was due to a broken spring. On the south rail,

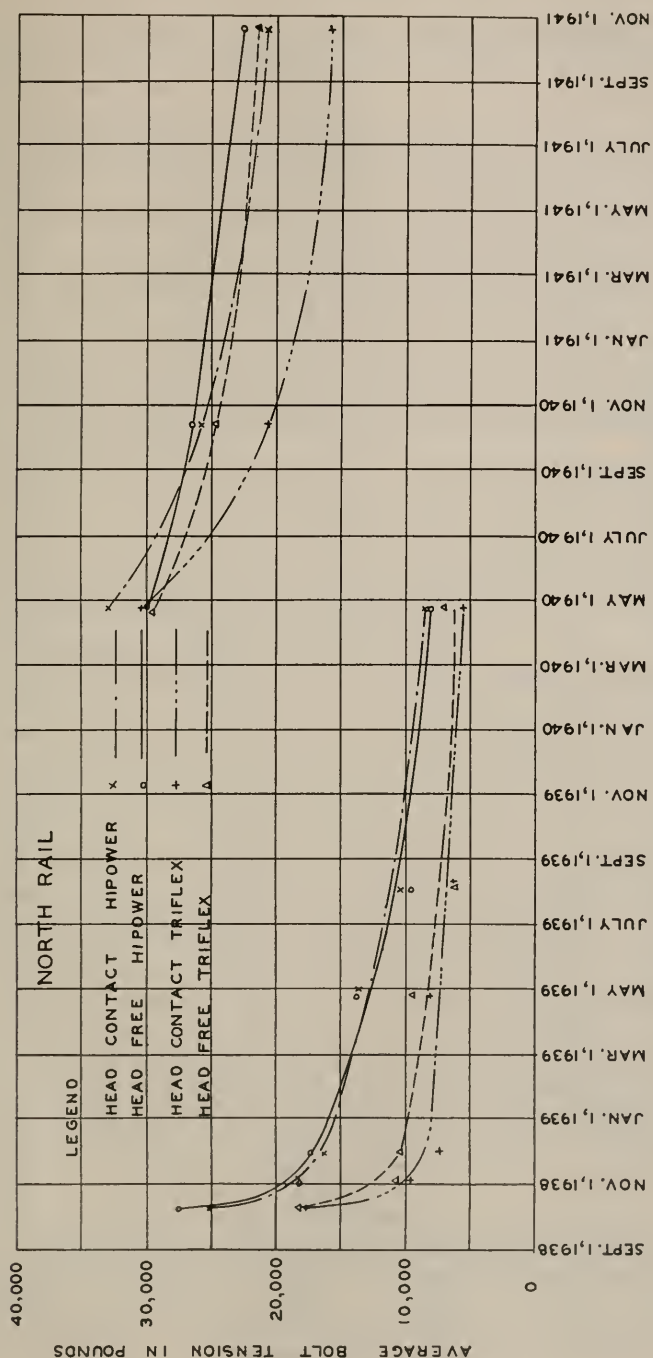


Fig. 1.—Loss of Bolt Tension Under Traffic—C. B. & Q. Installation

Original tightening October 5, 1938. Retightened April 25, 1940. Approximate traffic density 15,000,000 gross tons per year.

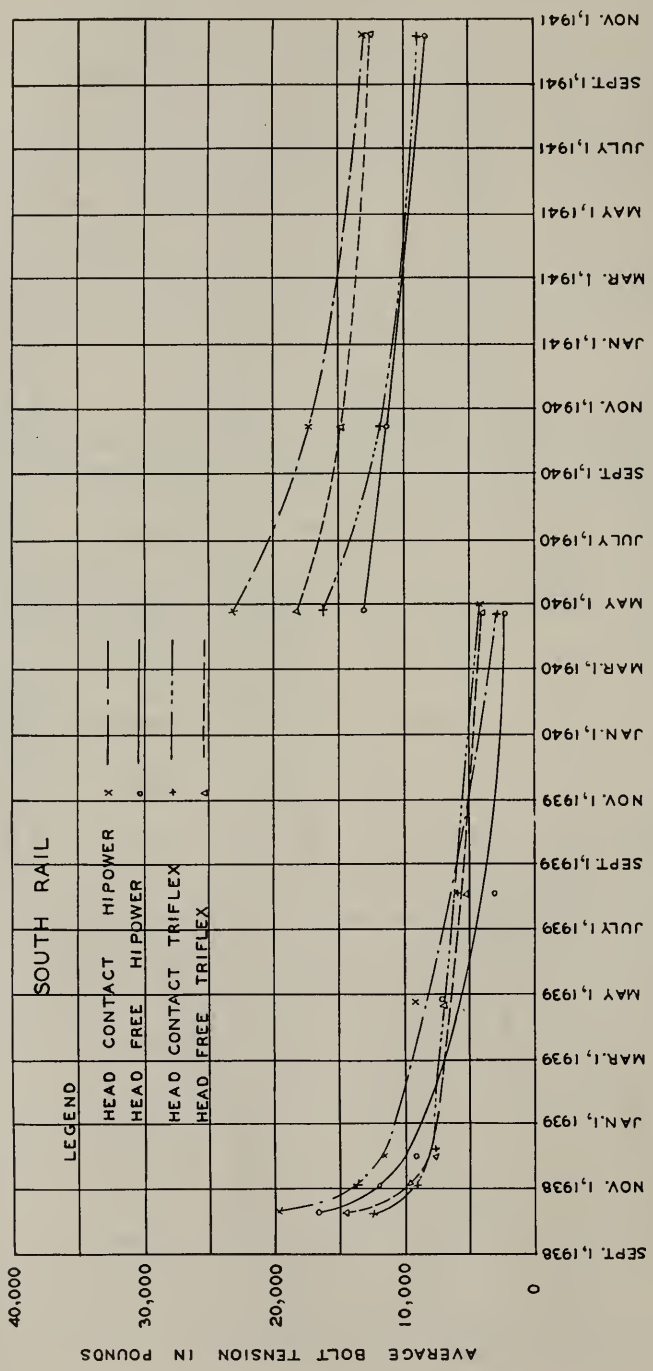


Fig. 2.—Loss of Bolt Tension Under Traffic—C. B. & Q. Installation

Original tightening October 5, 1938. Retightened April 25, 1940. Approximate traffic density 15,000,000 gross tons per year.

with the lower initial tension there were a comparatively large number of loose bolts, particularly on the headfree Hipower test section which had an initial tension of 13,110 lb.

Wear of Joint Bars and Rail Fishing Surfaces

Out-to-out measurements of joint bars were again taken as described in last year's report (page 613, AREA Proceedings, Vol. 42) to obtain information on wear of joint bar and rail fishing surfaces. In Table 4 the average change in out-to-out distance of joint bars for the eight test sections is given separately for each position of measurement on the bar. By comparison with the corresponding measurements reported last year, it will be noted that very little inward movement of the bars towards the rail occurred on the north rail and also for the headfree bars on the south rail. The head contact bars showed an average inward movement for this year's period of 0.007 in. (Hipower) and 0.009 in. (Triflex). In general, however, after three years' service there is no clearly defined difference in fishing surface wear between the north rail and south rail irrespective of the fact that the north rail has been maintained at much higher bolt tension throughout the test period.

It should be noted that the headfree bars show little inward movement towards the rail at the top of the bar, but about the same or a little more at the bottom than the head contact bars. The average inward movement is therefore considerably less for the headfree bars than for the head contact bars. This fact and the greater loss in bolt tension with the head contact bars seem consistent with laboratory test to determine the reactive properties of the Triflex and Hipower springs.

Reactive Strength of Spring Washers and Bolts

There are at least four possible ways in which bolt tension may be lost: (a) Backing off of the nut with train vibration; (b) stretch of the bolt due to stress above the elastic limit resulting from flexure of the joint under traffic; (c) inward movement of the bars toward the rail as a result of bar and rail fishing surface wear; and (d) bending of the bolt by high pressures exerted by the rail web in the case of unduly wide joint-gap opening. No work has been done by the committee on items (a) and (b) because previous work by others had indicated that ordinarily these factors were not very important. The effect of items (c) and (d) will obviously depend upon the reactive qualities of the rail, bar, bolt and spring washer assembly. Accordingly it was decided to make some laboratory tests, and through the courtesy of the Burlington Railroad these tests were made in that company's laboratory at Aurora, Ill.

It was not practical to duplicate the entire rail and bar assembly. Two stirrups were prepared, one of which was placed in the upper, and the other in the lower set of jaws of a testing machine. A regular track bolt, or bolt and spring washer, was then placed to join these two stirrups. The bolt was first loaded to 40,000 lb. tension and released, four times. It was then loaded to 40,000 lb. tension and an accurate reading was taken with the joint bar caliper of the distance between the bolt-bearing surfaces of the stirrups. Bolt tension was then released in increments and measurements taken of the change in this distance between the stirrups. The results of the test are shown in Fig. 3.

The purpose of this test was not to compare the values of the different springs, but to derive information which would be helpful in explaining results found in track tests. For example, the relative reactance value of the springs will depend upon the amount of initial bolt tension. The tension of 40,000 lb. was selected for laboratory test because information was desired over the entire range of bolt tension that might be found in track.

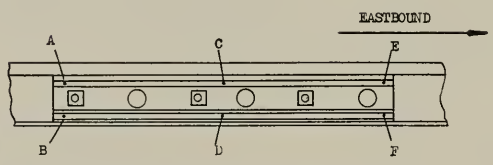
Table 3. - Average Loss in Bolt Tension from April 25, 1940 to October 16, 1941.

Average Bolt Tension in Lb.

South Rail	4-25-40	10-16-41	Loss	Loss Per Month	No. of Bolts in Test	No. Bolts Loose 10-16-41
Headfree Triflex	18,400	12,480	5,920	330	60	0
Headfree Hi Power	13,110	7,970	5,140	290	57	13
Head contact Triflex	16,360	8,670	7,690	430	51	5
Head contact Hi Power	23,190	12,900	10,290	580	53	6
North Rail						
Headfree Triflex	29,610	21,640	7,970	450	54	1*
Headfree Hi Power	29,820	22,420	7,400	420	53	1
Head contact Triflex	30,100	15,650	14,450	820	41	0
Head contact Hi Power	32,850	20,590	12,260	690	58	0

* Broken Spring.

TABLE 4.



Average Change in Out-to-Out Distance of Joint Bars
C. B. & Q. R.R. Test Installation
(From October 5, 1938 to October 16, 1941)

Type of Joint & Spring Washer	Location of Joint						
North Rail:	A	B	C	D	E	F	Ave.
Headfree Hipower	.000	- .056	- .036	- .086	- .023	- .071	- .045
Headfree Triflex	- .017	- .046	- .033	- .074	- .022	- .061	- .042
Head Contact H.P.	- .041	- .019	- .070	- .062	- .064	- .051	- .051
Head Contact Tri.	- .068	- .050	- .113	- .082	- .061	- .049	- .070
South Rail:							
Headfree Hipower	.005	- .041	- .024	- .087	- .013	- .074	- .039
Headfree Triflex	.009	- .050	- .025	- .098	- .010	- .089	- .044
Head Contact H.P.	- .054	- .030	- .115	- .089	- .085	- .068	- .074
Head Contact Tri.	- .066	- .050	- .116	- .103	- .078	- .057	- .078

Note: All values shown are in inches. The "-" sign indicates the average change is a decrease in out-to-out distance.

Actually, these laboratory data have been of use in explaining results obtained in the bolt tension measurements in the field. For example, field measurements have indicated about the same inward movement towards the rail of joint bars regardless of bolt tension. Yet there is unquestionably a higher rate of bolt tension loss with high initial tension. Fig. 3 shows that for a release of the bolt and double-coil Hipower spring of

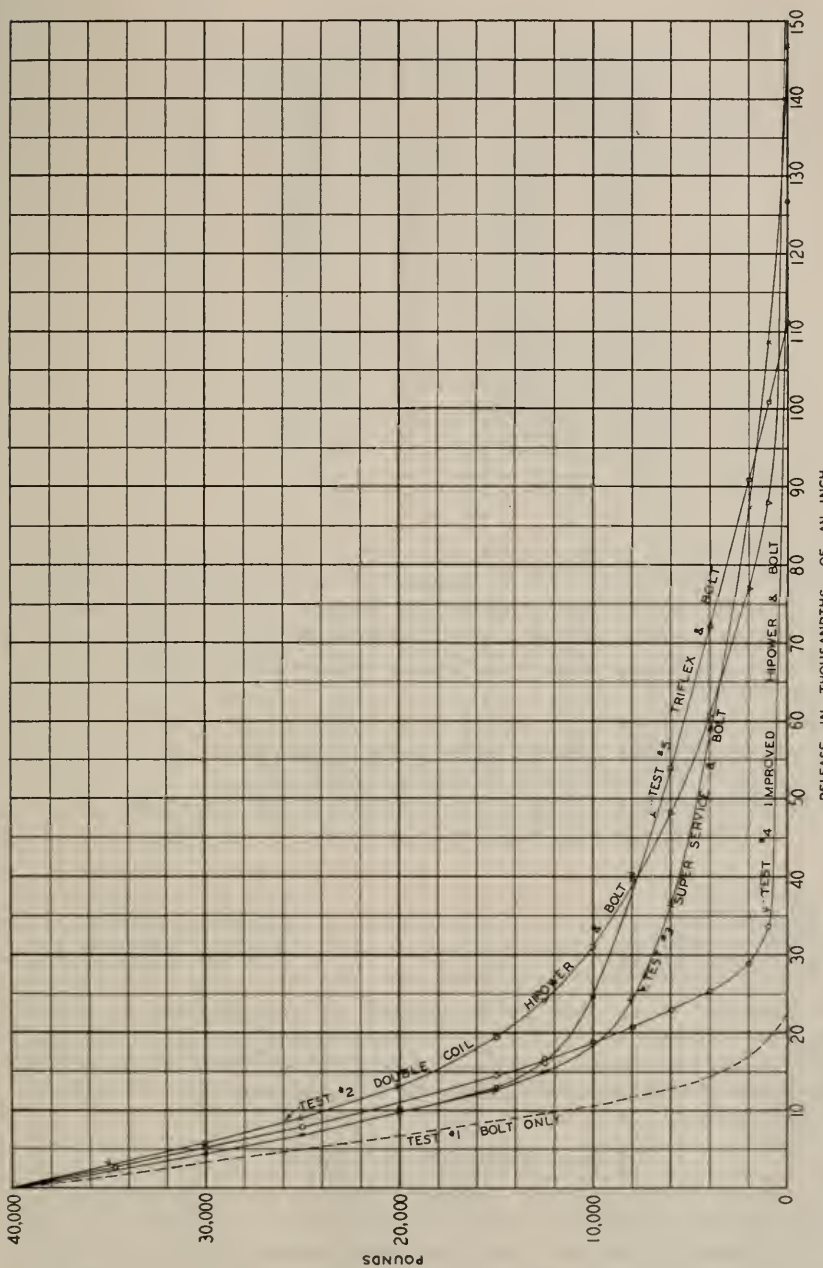


Fig. 3.—Reaction of Bolt and Spring Washer

Laboratory test at Aurora, Ill., June 13, 1941. All tests with same bolt (1 in.), each washer compressed to 40,000 lb. four times before test.

TABLE 5

Bolt Tension - D.&R. G. W. Test

(Values given are averages per joint per bolt in lb.)

	North Rail			South Rail	
	Bolt Tension			Bolt Tension	
	Applied	Remaining		Applied	Remaining
Joint No.	10/11/40	7/10/41	Joint No.	10/11/40	7/10/41
1	31,700	22,400	26	19,000	14,500
2	40,200	30,500	27	27,100	26,400
3	28,600	24,500	28	35,000	34,500
4	40,000	35,200	29	24,500	22,600
5	32,800	22,800	30	22,800	19,800
6	15,500	10,000	31	30,700	29,800
7	28,600	25,900	32	24,800	20,700
8	16,200	11,900	33	24,300	21,200
9	15,000	14,800	34	17,900	17,900
10	15,200	11,900	35	20,700	17,100
11	30,200	22,400	36	36,700	32,600
12	26,400	23,800	37	26,900	18,600
13	17,400	14,000	38	13,800	9,500
14	13,600	15,000	39	30,000	23,300
15	32,100	23,800	40	18,300	14,000
16	14,800	10,200	41	36,200	36,200
17	27,100	22,400	42	22,600	15,500
18	19,500	12,800	43	15,000	8,300
Average	24,700	19,700		24,800	21,200

0.005 in. from an initial tension of 30,000 lb. the bolt tension would drop to 22,500 lb.; but from an initial tension of 15,000 lb. the bolt tension would drop only to 12,300 lb.

On the south rail the Triflex springs with the head contact bars show less bolt tension loss than the double-coil Hipower. On the north rail, however, the Hipower springs show less loss. This is not inconsistent, however, if the initial tensions and the reactance curves are considered.

The out-to-out measurements showed greater inward movement towards the rail with the head contact bars. This fact applied to the reactance curves is consistent with the greater loss of bolt tension found with the head contact bars.

If the reactance curves be applied to the initial and final bolt tensions given in Table 3, the following values for equivalent release of the bolt are obtained:

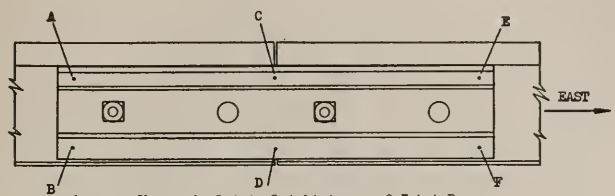
	South Rail	*North Rail*
Headfree Triflex	0.006 in.	0.005 in.
Headfree Hipower	0.016 in.	0.005 in.
Head-contact Triflex	0.021 in.	0.008 in.
Head-contact Hipower	0.013 in.	0.008 in.

The equivalent release values for the north rail are perfectly consistent, showing the same bar movement with both types of springs on each type of bar and more movement of the head contact than headfree bars. The values for the south rail are erratic which is probably due to the range in tension covering the "critical" portion of the reaction curves.

Denver & Rio Grande Western

The rail was laid for this test installation on the single track main line of the Denver & Rio Grande Western near Glenwood Springs, Colo., on September 7, 1938 (See Vol. 40, page 568). The rail is 131-lb., with 4-hole toeless joint bars, 1⅛ in. heat-treated bolts, and National grooved spring washers. To continue the test, as described in last year's report, all test bolts were replaced with new bolts on October 11, 1940

TABLE 6.



Average Change in Out-to-Out Distance of Joint Bars
D. & R. G. W. Test Installation
(From September 7, 1938 to July 10, 1941)

Joint No.	Position A	B	C	D	E	F
			North Rail			
1	- .009	.003	- .013	- .013	- .032	- .020
2	- .020	- .012	- .028	- .023	- .016	- .003
3	.006	.003	- .010	- .025	.009	- .011
7	- .019	.002	- .025	- .008	- .006	.001
8	- .039	- .029	- .051	- .041	- .011	.007
9	.033	- .022	.009	- .028	.009	- .020
11	.003	- .025	- .021	- .039	- .007	- .023
12	- .007	- .032	- .013	- .042	- .003	- .028
13	.017	- .018	.005	- .040	.001	- .063
14	- .072	- .073	- .037	- .027	.009	.011
15	.014	- .001	- .011	- .028	- .006	- .026
16	.107	- .126	.104	- .125	.076	- .152
17	.025	- .020	- .003	- .024	.003	- .009
18	.052	- .168	.076	- .139	- .150	- .103
Average	.006	- .037	- .001	- .043	.013	- .031
			South Rail			
26	- .001	- .024	.002	- .031	.000	- .033
27	- .013	- .017	- .017	- .017	- .021	- .008
29	- .007	- .017	- .006	- .021	- .020	- .031
30	- .013	- .040	- .010	- .040	- .006	- .037
32	- .008	- .016	- .013	- .030	- .018	- .028
33	.001	- .056	- .002	- .049	- .007	- .052
34	.005	- .035	- .013	- .056	- .033	- .064
35	- .086	- .081	- .034	- .037	- .015	- .048
36	.001	- .009	- .021	- .027	- .022	- .032
38	- .050	- .037	- .042	- .031	- .039	- .017
40	- .028	- .071	- .008	- .043	.021	- .022
41	- .042	- .081	- .023	- .066	.013	- .028
42	- .076	- .071	- .042	- .046	- .014	- .012
43	- .038	- .007	- .069	- .035	- .065	- .048
Average	- .025	- .040	- .021	- .038	- .016	- .033

Note: Measurements in inches. Minus sign = decrease in out-to-out distance

which bolts were tightened by hand. It was desired to obtain a tension of about 25,000 lb. on the south rail and 50,000 lb. on the north rail. Actually, however, about the same average tension (25,000 lb.) was obtained in both rails.

Loss of Bolt Tension Under Traffic

The bolts were left undisturbed following the October 11, 1940, tightening; and on July 10, 1941, the remaining bolt tension was measured. The average values per joint are given in Table 5, and in Fig. 4 the loss in tension curves for the north and south rails have been extended to include this last series of measurements. The average loss in tension for all bolts for this 9-month period was 4,300 lb., or 478 lb. per month. As in other tests, the loss was not uniform at all joints. Some joints lost much more than this amount of bolt tension and others lost none or a very little. Observation indicated that those joints showing least expansion and contraction movements of the rail ends within the joint bars had least bolt tension loss.

A

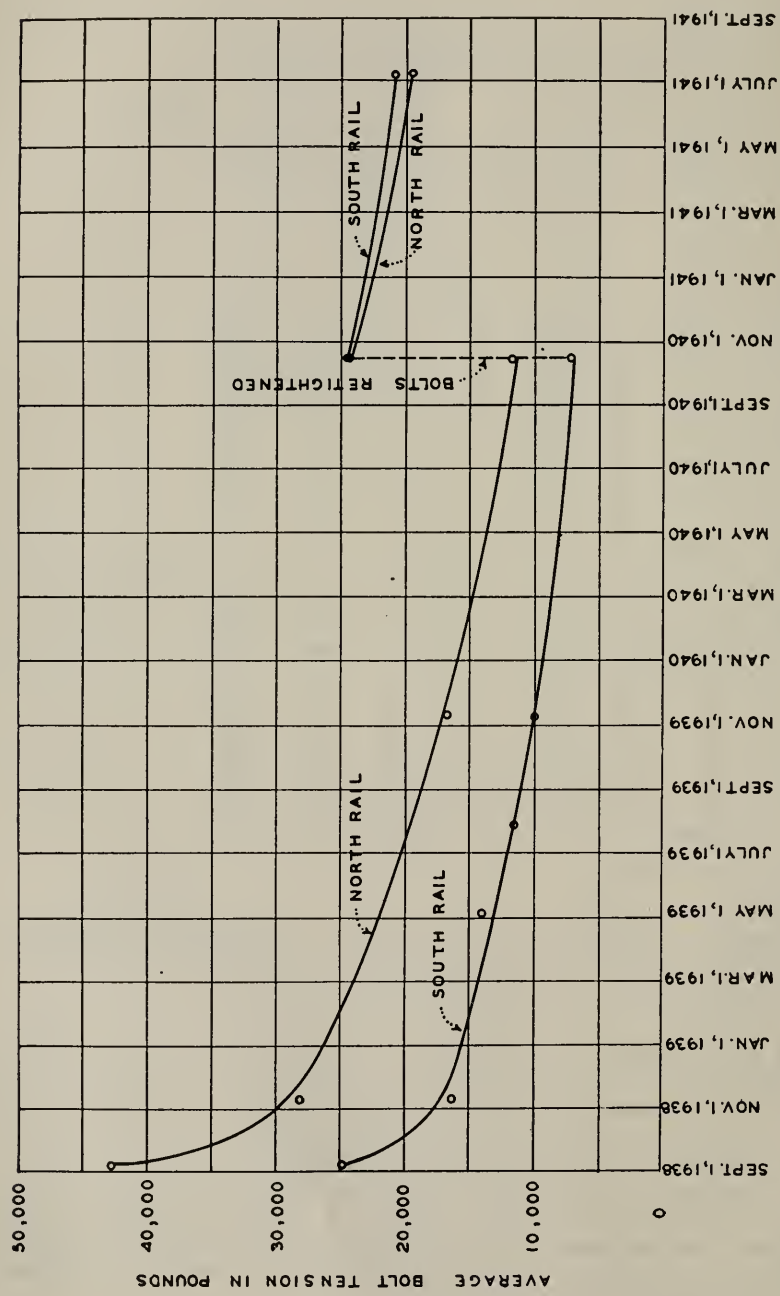


Fig. 4.—Loss of Bolt Tension Under Traffic—D. & R. G. W. Installation

Rail laid and bolts tightened September 7, 1938. Bolts retightened October 10, 1940. Approximate traffic density 3 to 5 million gross tons per year, exclusive of locomotives and passenger trains.

TABLE 7

Bolt Tension Measurements

P.R.R. Test Installation
Average Bolt Tension Per Joint - Lb.

Joint No.	Applied 11-14-40	Remaining 7-2-41	Loss 11-14-40 to 7-2-41	Reapplied 7-2-41	Remaining 11-5-41	Loss 7-2-41 to 11-5-41
1	21,700	14,600	7,100	21,900	20,800	1,100
2	27,800	15,700	12,100	18,300	14,100	3,200
3	24,500	13,000	11,500	15,200	12,100	3,100
4	27,500	15,200	12,300	20,900	20,000	900
5	21,500	13,000	8,500	18,300	15,400	3,100
6	28,800	19,000	9,800	19,000	18,100	900
7	21,100	13,000	8,100	17,800	14,700	3,100
8	22,200	14,300	7,900	15,200	12,100	3,100
9	20,600	12,900	7,700	18,400	15,100	3,300
10	31,000	20,600	10,400	23,200	22,500	700
11	23,300	14,300	9,000	17,200	16,600	600
12	24,000	13,000	11,000	17,400	16,800	600
13	27,500	19,500	8,000	19,500	18,400	1,100
14	26,700	19,800	6,900	19,800	19,100	700
15	29,300	19,800	9,500	19,800	17,200	2,600
16	25,500	20,100	5,400	20,100	16,400	3,700
17	27,000	23,100	3,900	26,400	24,700	1,700
Average	25,300.	16,500	8,800	19,300	17,300	2,000

Average Bolt Tension by Bolt Position
(See Table 8 for Bolt Position)

Bolt Pos.						
1	23,800	16,700	7,100	19,600	18,900	700
2	28,200	19,700	8,500	19,700	19,200	500
3	26,200	15,500	10,700	21,600	16,200	5,400
4	26,200	14,900	11,300	19,000	15,600	3,400
5	24,500	18,200	6,300	19,000	18,400	600
6	23,700	14,100	9,600	16,800	14,900	1,900

Note: Compare with AREA Vol. 42, page 626.

It was necessary to discontinue readings on joints 19 to 25, inclusive, and 44 to 50, inclusive, because these joints were on rails that had been transposed on curved track because of rail wear.

Out-to-Out Measurements of Joint Bars

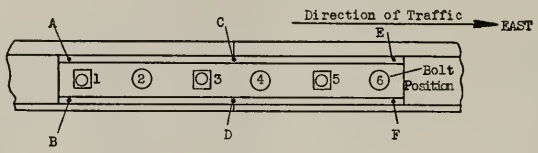
Out-to-out distance of joint bars was also measured on July 10, 1941, and the results are shown in Table 6. This table should be compared with Table 6, page 618 of AREA Proceedings Vol. 42. Until October 10, 1940, the bars had moved inwardly towards the rail about the same amount at both top and bottom. Since placing the new bolts, however, there has been a marked change in this movement. Since October 10, 1940, the bars have moved outwardly at the top and inwardly towards the rail at the bottom on the north rail and on the south rail at the top of the bars there has been little change, but at the bottom of the bars considerable inward movement toward the rail has occurred.

Pennsylvania Railroad

This test was installed August 26, 1939, near Birmingham, Pa. on the Pennsylvania Railroad main track No. 1, carrying eastbound passenger and freight traffic. The traffic density is very high, running between 50 to 70 million gross tons per year. The rail is 152-lb. Pennsylvania section, with 6-hole toeless controlled-bearing joint bars, 1⅛-in.

Table 8.

P.R.R. Test Installation



Average Change in Out-to-Out Measurement at Locations Shown

Location	Out-to-Out Change (Inches)	
	11-14-40 to 7-2-41	7-2-41 to 11-5-41
A	- .004	- .001
B	- .011	- .003
C	- .001	- .010
D	- .016	- .014
E	- .003	- .008
F	- .014	- .008
Average	- .008	- .007

Note: The minus sign indicates a decrease in out-to-out measurement.

bolts and low reactance spring washers (See AREA Proceedings Vol. 41, page 588). The track bolts were Pennsylvania standard bolts having class-two fit, rather than the AREA specification wrench-turn fit. Also, the test bolts were all specially tested to insure that the nut could be run over the entire length of the threaded portion of the bolt by hand.

Loss of Bolt Tension Under Traffic

Continuing the work previously reported, the test bolts were retightened with a hand wrench on November 14, 1940, and measurements taken of the bolt tension applied. Bolt tension measurements were repeated on July 2, 1941, and some of the bolts were retightened where the tension was found to be below 15,000 lb. No bolts were loose; and the lowest tension found was 9,000 lb. Measurements were again taken November 5, 1941; and no loose bolts were found at this time, the lowest tension remaining in any bolt being 5,000 lb. Table 7 shows the average bolt tension per joint at each period of measurement.

It will be noted that the loss in bolt tension for the eight-month period from November 14, 1940, to July 2, 1941, was more than proportionately greater than for the four-month period from July 2, 1941 to November 5, 1941. The reason for this is as yet unknown. In both periods, however, the loss in bolt tension was considerably greater for the two inner bolt positions than for the remaining four positions.

Out-to-Out Measurements of Joints

On November 14, 1940, at the time the bolts were retightened, measurements were made of the out-to-out distance of joint bars on both top and bottom ribs at each end and at the middle of each joint. These measurements were repeated on July 2, 1941, and again on November 5, 1941, and the average change in out-to-out distance during

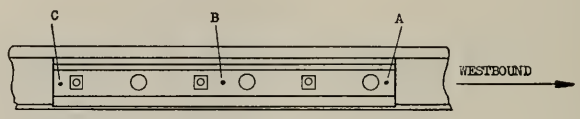
TABLE 9.

BOLT TENSION MEASUREMENTS
Erie R. R. Test Installation

Joint No.	Bolt Tension Applied in Retightening - October 15, 1940							Joint No.	Bolt Tension Remaining - December 3, 1941						
	Bolt Position								Bolt Position						
	1	2	3	4	5	6	Average		1	2	3	4	5	6	Average
						Chrome Hipower Spring Washers									
1-N	22,300	23,100	14,900	13,200	20,600	19,800	18,980	1-N	22,280	23,100	10,730	9,080	18,980	17,320	16,910
2-N	13,200	14,000	22,300	15,700	13,200	15,700	15,680	2-N	4,120	13,200	17,330	9,900	9,080	14,020	11,275
3-N	22,300	13,200	14,000	-	-	-	16,500	3-N	19,800	10,720	10,720	-	-	-	13,746
1-S	14,000	11,600	11,600	13,200	8,200	14,000	12,100	1-S	10,720	6,600	4,950	7,420	7,420	6,600	7,285
2-S	16,500	14,900	17,300	18,200	-	18,200	17,020	2-S	10,720	14,020	10,720	9,070	-	14,850	11,876
3-S	19,000	9,900	14,900	6,600	19,000	13,200	13,770	3-S	18,150	8,250	9,070	3,300	13,200	9,080	10,175
Average	17,880	14,450	15,830	13,380	15,250	16,180	15,600	Average	14,300	12,650	10,590	7,750	12,170	12,370	11,700
						Triflex Springs									
3-N	-	-	-	16,300	13,200	13,200	14,230	3-N	-	-	-	10,080	10,850	10,070	10,175
4-N	17,800	14,000	17,800	14,000	11,600	14,000	14,870	4-N	13,170	10,070	10,850	11,625	7,750	9,300	10,460
5-N	14,700	13,200	21,000	15,500	12,400	14,700	15,250	5-N	11,620	10,070	13,950	11,625	8,520	11,625	11,235
4-S	29,500	17,000	12,400	8,500	11,600	10,100	14,850	4-S	28,700	14,720	10,850	4,650	7,750	9,300	12,661
5-S	7,700	14,700	8,500	3,800	11,600	12,400	9,780	5-S	6,980	10,850	7,750	2,320	10,070	9,300	9,300
6-S	14,700	14,000	10,800	11,600	8,500	10,850	11,740	6-S	13,170	11,620	7,750	12,400	8,520	9,300	10,460
Average	16,880	14,580	14,100	11,620	11,480	12,540	13,380	Average	14,730	11,470	10,230	8,780	8,910	9,810	10,780
						Hipower Spring Washers									
6-N	19,800	18,200	19,800	22,300	18,200	20,600	19,820	6-N	17,320	17,320	15,680	18,150	14,850	16,500	16,636
7-N	22,300	21,400	11,600	5,800	18,200	13,200	15,420	7-N	19,800	17,320	8,250	3,300	18,150	10,720	12,923
8-N	16,500	23,100	15,700	10,700	12,400	15,700	15,820	8-N	12,380	18,980	9,900	10,720	7,425	14,020	12,237
7-S	11,600	11,600	9,100	14,900	11,600	20,600	13,230	7-S	7,420	6,600	4,950	9,900	9,080	18,150	9,350
8-S	20,600	9,900	13,200	16,500	3,300	13,200	12,780	8-S	15,680	6,600	9,080	12,380	820	12,380	9,690
9-S	12,400	11,600	8,300	9,900	15,700	15,700	12,270	9-S	4,950	4,950	4,120	8,250	13,200	17,320	8,798
10-S	6,600	17,300	5,800	-	-	-	9,900	10-S	4,950	12,380	1,650	-	-	-	6,330
Average	15,690	16,160	11,930	13,350	13,230	16,500	14,480	Average	11,780	12,020	7,660	10,450	10,590	14,850	11,170

Note: Bolt positions are numbered from west to east against the direction of traffic.
All bolt tension measurements shown are in pounds.

TABLE 10.



Change in Out-to-Out Measurement of Joint Bars
Erie R.R. Test Installation

October 15, 1940 to December 3, 1941.

Joint No.	Position of Measurement A	B	C
	Chrome Hipower Spring Washers		
1-N	- .004	- .009	- .001
2-N	.004	- .009	- .005
3-N	- .001	- .011	.005
1-S	- .006	- .013	- .020
2-S	- .008	- .011	- .004
3-S	- .003	- .002	- .003
Average	- .003	- .009	- .005
	Triflex Springs		
3-N	- .001	- .011	.005
4-N	- .008	- .032	- .001
5-N	- .005	- .048	- .005
4-S	- .006	- .030	- .003
5-S	- .007	- .005	- .019
6-S	- .010	- .015	.001
Average	- .006	- .023	- .004
	Hipower Springs		
6-N	- .002	- .005	- .001
7-N	- .001	- .002	- .003
8-N	.001	.001	.003
7-S	- .006	- .007	- .001
8-S	- .009	- .006	- .001
9-S	- .012	- .007	- .004
10-S	- .014	- .010	- .003
Average	- .006	- .005	- .001

Note: Measurements shown represent decrease in out-to-out distance of joint bars if preceded by a (-) sign. All out-to-out measurements shown are in inches.

these two test periods is shown in Table 8. The change in out-to-out distance is a measure of the fishing surface wear of the rail and joint bars.

Between November 14, 1940, and July 2, 1941, the bars showed very little inward movement toward the rail at the top of the bars, most of the inward movement occurring at the bottom of the bars. Between July 2, 1941, and November 5, 1941, both top and bottom of the bars moved in about the same. Considering the extremely high traffic density carried, the amount of inward movement of the bars is remarkably small.

Erie Railroad

The test installation on the Erie Railroad is on the westbound track of the double-track main line at M.P. 223, near Griffith, Ind. The rail is 112-lb. section laid new on July 19, 1939, with 6-hole angle bars and 1-in. heat-treated bolts. The test installation consists of 8 joints on the north rail and 10 joints on the south rail, a total of 18 joints and 105 test bolts. Triflex springs were placed on 33 of the test bolts, chrome improved Hipower spring washers on 33, and improved Hipower spring washers on 39. The traffic carried over this track in 1940 was 7,660,280 gross tons.

Loss of Bolt Tension Under Traffic

At the time of the October 15, 1940, measurements reported last year, the test bolts were all retightened by hand wrenching and measurements made of the bolt tension applied. The bolts were then left undisturbed until May 22, 1941, at which time the bolt tension measurements were repeated. The loss in bolt tension that had occurred in this interval of seven months was surprisingly small. In view of the small change in bolt tension, the bolts were not retightened. Then, on December 3, 1941, the bolt tension was again measured. This represented a period of more than 14 months since the bolts were last tightened. In Table 9, individual bolt tension measurements are given for each bolt included in the test, for the bolt tension applied on October 15, 1940, and the bolt tension remaining December 3, 1941. No bolts were found entirely loose, although a few had very little tension remaining.

It will be noted from Table 9 that the average loss in bolt tension was as follows:

Chrome Hipower spring washers	3,900 lb.
Triflex springs	2,600 lb.
Hipower spring washers	3,310 lb.

The average loss in bolt tension over the 14-month period was small for all 3 test sections.

Out-to-Out Measurements of Joint Bars

At the time of making the bolt tension measurements, the out-to-out distance between joint bars was measured with the joint-bar caliper on the center line of each joint bar near each end and at the middle. Readings could not be taken between the bottom flanges with the caliper because the joint bars were of the angle bar type, and the caliper would not span the outstanding flanges.

In Table 10 is given the change in out-to-out distance as determined from measurements made October 15, 1940, and December 3, 1941. These correspond fairly well with similar measurements reported last year except that the change in general is somewhat smaller. This indicates that the rate of fishing surface wear has been somewhat less during this latter period. The bars continue to show somewhat greater inward movement towards the rail at their centers than at their ends, and three of the joints in the Triflex section showed exceptionally large inward movement at their center.

Reactive Strength of Spring Washers and Bolts

In Fig. 3 the reactive curves for the improved Hipower spring washer, Triflex spring, and bolt are given. It is then possible to apply the initial and final bolt tensions given in Table 9 to these reactive curves and determine what "equivalent release" between joint bar surfaces might be anticipated to produce the actual loss in bolt tension based upon reactive strength of the bolt and type of spring washer used. This "equivalent release" can then be compared with the actual measured change in out-to-out distance. Bolt position 1 is comparable with out-to-out measurement location A; the average of bolt positions 3 and 4, location B; and bolt position 6, location C. *(see next page)*

The following comparison consistently shows a definite relation between the change in out-to-out measurement and "equivalent release" of bolt and spring washer. This shows that the loss in bolt tension is directly affected by change in "out-to-out" joint bars. However, the loss in bolt tension was not nearly as great as would be expected from the reactance curves and the change in out-to-out measurements. It does not seem possible that the reactance values of the bolts and springs could be appreciably greater than shown by Fig. 3. It is hoped that continued investigation will disclose the explanation for this discrepancy.

Comparison of Equivalent Release and Change in Out-to-Out Distance

Bolt Position	*Equivalent Release Inches*	*Bar Position*	*Average Change in Out-to-Out Inches*
Chrome Improved Hipower Spring Washers			
1	0.002	A	0.003
3	0.004	B	0.009
4	0.005		
6	0.003	C	0.005
Triflex Springs			
1	0.002	A	0.006
3	0.0095	B	0.023
4	0.0165		
6	0.009	C	0.004
Improved Hipower Spring Washers			
1	0.003	A	0.006
3	0.004	B	0.005
4	0.003		
6	0.001	C	0.001

Report on Assignment 11

Prevention of Damage Due to Brine Drippings on Tracks and Structures, Collaborating with Mechanical Division, AAR

G. M. Magee (chairman, subcommittee), W. G. Arn, C. W. Baldridge, H. R. Clarke, F. W. Hillman, C. T. Jackson, F. J. Jerome, C. R. Strattman, Hermann von Schrenk, J. G. Wishart.

The following report is presented as information.

As mentioned in the report for last year, a series of track tests were planned to check the results obtained in the laboratory with sodium dichromate inhibitor added to brine solutions. In these tests it was the intention to spray a section of rail and tie plates daily for a 90-day period with salt solution and to spray a corresponding section daily for the same period with salt solution containing the inhibitor. Protection against corrosion was to be determined by weight loss of the tie plates and special discs.

The tests were carried out in the laboratories of the Chicago, Milwaukee, St. Paul & Pacific and the Denver & Rio Grande Western.

Milwaukee Laboratory Report

This test was started on September 7, 1940, but was delayed until September 18, because of oiling activities which coated all of the test material and made it necessary to remove the tie plates and discs for cleaning, weighing and replacement. The procedure in the test was as follows:

(a) A new rail was laid in the westbound main line at Milwaukee Shops near the 36th Street foot bridge.

(b) Six new tie plates were installed on successive ties near each end of the rail and three near the center.

Installation of Test Tie Plates on the Milwaukee Railroad.

(c) Test discs were fastened to the toe of each tie plate. These discs were supplied by the AAR from the same lot as were used in previous laboratory tests.

(d) Saturated salt solution, 50 cc, was applied to each of 6 plates and an alkaline solution, pH — 8, with sodium dichromate, 3.2 grams per liter, applied to 6 at the other end. No treatment was applied to the 3 plates and discs at the center of the rail.

(e) Three tie plates were laid away near the engine house to determine the rate of corrosion due to atmospheric conditions only because of the possibility of protection of the active plates due to oil and grease drippings.

(f) The results of the test are shown on the table.

RESULTS OF CORROSION TESTS, MILWAUKEE SHOPS—SEPTEMBER 18 TO DECEMBER 18, 1940.

	2" discs on Tie Plates Loss in grams per disc					Tie Plates Loss in grams per plate			
	Sat. Salt Solution	Sat. Salt Solution + Inhibitor	Discs in Center of Rail - No Treatment	Discs on Tie Away from Track No Treatment		Sat. Salt Solution	Sat. Salt Solution + Inhibitor	Plates* in Center of Rail - No Treatment	Plates* on Tie Away From Track No Treatment
1	2.699	.441	.834	1.127	1	79.2	27.9	32.0	34.0
2	1.633	.333	.811	1.163	2	74.8	23.2	29.7	41.3
3	2.157	.486	.959	1.173	3	77.3	23.0	31.0	48.5
4	1.236	.409			4	72.7	31.6		
5	1.131	.401			5	73.0	35.1		
6	.946	.369			6	64.0	28.8		
Average	1.633	.406	.868	1.161	Average	73.5	28.3	30.9	41.2

Weight of original discs 48 grams (± 1 gram)

Average Temperature 47°F

Rain 12 times (Average .27")

Snow 5 times (Average 1.8")

Duration of test - 92 days.

Weight of original plates 15 lbs. (-400 gr. +200 gr.)

* Corrosion products difficult to remove.

pH adjusted to 8.0 by addition of 4.7 gr./ liter sodium carbonate

One liter of water dissolved 345 grams of salt.

The salt used in this test was from the regular stock of crushed rock salt. An analysis follows:

	Percentages
Insoluble in water	2.81
Iron and aluminum oxides	Trace
Calcium chloride	3.17
Magnesium chloride	Trace
Sodium sulphate	4.02
Loss at 105 deg. C.	Trace
Sodium chloride	90.00

The corrosion losses in order are shown below:

Exposure	*Discs Grams*	*Tie Plates Grams*
Salt solution	1.633	73.5
Atmospheric	1.161	41.2
Untreated	.868	30.9
Inhibited	.406	28.3

This track is not subjected to heavy brine drippings, but the above results show the protective effect of an inhibited solution.

In connection with this test it is interesting to note the abstract of Research Paper RP 1305 National Bureau of Standards "Tests of Corrosion Inhibitors for Water Treatment in Air-Conditioning Equipment."

> Treatment of the circulating water used in air-conditioning equipment with small amounts of certain chemicals and control of the pH of this water greatly reduce the losses resulting from corrosion. The order of decreasing efficiency of the inhibitors studied was (a) chromates, (b) silicates, (c) phosphates, and (d) carbonates. The differences in the corrosion resistance of the various kinds of iron and steel used were slight in comparison with the effect of a change of inhibitor or condition of test.

Rio Grande Laboratory Report

Twelve 112-lb. tie plates were sand blasted and weighed and then put in the southbound main line track, just south of the West 8th Ave. viaduct at the Burnham Shops. Six tie plates were placed at each end of the rail. On each of the 12 test tie plates there was placed a two-inch control disc of steel as furnished by the AAR; these were fastened by drilling a hole in the center of the disc, and passing a wood screw through this hole and a spike hole in the tie plate.

One pint of test solution was placed on each set of six plates; that is, six plates were sprayed with saturated salt solution, and six plates with salt solution plus inhibitor, each morning and afternoon.

The solutions used in this test were made as follows:

> Two barrels were filled with 95 liters, (about 25 gal.) of water; in each of these barrels there was suspended a burlap bag that contained 75 lb. of rock salt. The contents of these barrels were stirred frequently for three days to get a saturated salt solution in each barrel.
>
> To the contents of one of these barrels there was then added, 3.2 g. per liter, or 304 g. of sodium dichromate, and 8.11 g. per liter of soda ash, (a little at a time), or 790 g., to get a pH of 8.

The two test solutions used were: One of a saturated salt solution, and, one of a saturated salt solution, plus 3.2 g. per liter of sodium dichromate and 8.11 g. per liter of soda ash.

Test was run from January 29 to April 29, 1941. During this period there was considerable snow and rain fall; and some nights when the temperature was below freezing.

It was noticed on March 12 after about a week of dry weather, that the tie plate sprayed with the inhibitor solution started to show signs of rusting, as long as the weather was wet and snow was on the ground these plates did not seem to rust.

Loss of Weight of Tie Plate and Control Discs

Plates and control discs, that were sprayed with saturated salt solution plus 3.2 g. per liter of sodium dichromate, and 8.11 g. per liter of soda ash to get a pH of 8, showed losses as follows:

Loss of Weight in Grams

No.	*Tie Plate*	*Control Disc*
1	20	0.5278
2	33	0.5542
3	28	0.2494
4	30	0.3148
5	35	0.3262
6	24	0.5522
Average	28	0.4208

Plates and control discs that were sprayed with saturated salt solution showed losses as follows:

Loss of Weight in Grams

No.	*Tie Plate*	*Control Disc*
7	68	1.7787
8	49	1.9241
9	49	1.9083
10	64	1.6123
11	60	1.5161
12	70	2.4030
Average	60	1.8571

Conclusions

The results of these track tests are in good agreement with the laboratory tests. It appears that the tests have proved beyond reasonable doubt the efficacy of the inhibitor in reducing brine corrosion. There are still problems in the practical application of the inhibitor, however, to be surmounted. The principle problem involves determination of means to apply the inhibitor, which is toxic if taken internally, in such manner that there may be no possible contamination of refrigerator car contents or other attendant hazard.

Report on Assignment 13

Specifications for High-Carbon Steel Track Spikes

E. E. Martin (chairman, subcommittee), A. L. Bartlett, F. J. Bishop, W. S. Boyce, O. U. Cook, W. E. Cornell, H. F. Fifield, J. W. Fulmer, N. M. Hench, F. W. Hillman, J. de N. Macomb, F. H. Masters, K. R. McLennan, M. J. T. Zeeman.

The following specifications are submitted as information with a view to offering them for adoption in the future.

SPECIFICATIONS FOR HIGH-CARBON STEEL TRACK SPIKES

I MANUFACTURE

101. Manufacture

The steel shall be made by the Open Hearth or by the Bessemer process as specified by the Purchaser.

II CHEMICAL AND PHYSICAL PROPERTIES

201. Chemical Requirements

(a) The steel shall conform to the following requirements as to chemical composition

	Open Hearth	*Bessemer*
Carbon, percent, not under	0.30	0.20

(b) For Open Hearth or Bessemer steel a carbon determination shall be made for each melt representing the average carbon content in the steel. These analyses shall be made from drillings taken at least ⅛ inch beneath the surface of the test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the Purchaser or his representative, and shall conform to the requirements specified in 201 (a).

202. Tensile Strength

(a) The Manufacturer may, at his option, substitute tension tests for the chemical analysis specified in 201 (a) in which case the finished spike shall conform to the following minimum requirements as to tensile properties:

Tensile strength, pounds per square inch	70,000
Yield point, pounds per square inch	½ tensile strength
Elongation in 2 inches, percent	25

(b) When option is exercised, one tension test shall be made from each lot of ten tons or fraction thereof.

203. Copper Content

When copper is specified by the Purchaser, the percentage contained in the steel shall not be less than 0.20 of 1 percent.

204. Bend Tests

(a) The body of the full size finished spikes shall bend cold through 120 degrees around a pin, the diameter of which is equal to the thickness of the spike without cracking on the outside of the bent portion.

(b) The head of the full sized finished spikes shall stand being bent backwards to an angle of 55 degrees with the line of the face of the spike, without cracking on the outside of the bent portion.

(c) One bend test of 204 (a) and one bend test of 204 (b) shall be made from each lot of five tons or fraction thereof.

III WORKMANSHIP AND FINISH

301. Workmanship

(a) The finished spikes shall conform to the dimensions specified by the Purchaser with the following permissible variations:

(b) A variation of $\frac{1}{32}$ inch over and $\frac{1}{64}$ inch under the specified cross-section dimensions of the body of the spike, measured from the face to the back, and across the face.

(c) A variation of $\frac{3}{32}$ inch over and $\frac{1}{32}$ inch under the specified dimensions of the width and length of the head of the spike.

(d) A variation of $\frac{1}{8}$ inch over and $\frac{1}{8}$ inch under the specified length of the spike, measured from the under side of the head to the point.

(e) A variation of 1 degree more and 1 degree less in the specified angle of underside of spike head.

302. Finish

All finished spikes shall be smooth and straight, with well formed heads, sharp points, and be free from nicks, checks, cracks, or ragged edges, and shall be finished in a workmanlike manner.

IV MARKING AND INSPECTION

401. Marking

A letter or brand indicating the Manufacturer and also the letters "HC" (indicating high carbon) shall be pressed on the head of each spike while it is being formed. When copper is specified, the letters "OU" shall be added.

402. Inspection

(a) The inspector representing the Purchaser shall have free entry, at all times, while work on the contract of the Purchaser is being performed, to all parts of the Manufacturer's works which concern the manufacture of the spikes ordered. The Manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy himself that the spikes are being furnished in accordance with these specifications. All tests and inspections shall be made at the place of manufacture, prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(b) Spikes which do not meet the requirements of these specifications will be rejected.

(c) Spikes which show injurious defects subsequent to their acceptance at the Manufacturer's works or elsewhere will be rejected.

Report of Committee 4—Rail

W. H. Penfield, *Chairman,*
J. B. Akers
W. T. Alexander
J. E. Armstrong
S. E. Armstrong
W. J. Backes
W. C. Barnes
L. H. Bond
N. J. Boughton
W. J. Burton
H. A. Cassil
E. E. Chapman
H. R. Clarke
E. J. Cullen
W. A. Duff
J. M. Farrin
P. O. Ferris
F. W. Gardiner
C. J. Geyer
F. M. Graham
J. L. Gressitt
G. W. Harris
E. M. Hastings
B. Herman
F. S. Hewes
W. H. Hillis
Maro Johnson
W. H. Kirkbride
B. R. Kulp
G. M. Magee
R. W. Marye
Ray McBrian
C. E. Morgan
E. E. Oviatt
C. B. Bronson, *Vice-Chairman,*
J. C. Patterson
Philip Petri
G. A. Phillips
B. H. Prater
A. N. Reece
J. C. Ryan
L. H. Scheifele
R. T. Scholes
F. S. Schwinn
G. R. Smiley*
A. N. Talbot
Barton Wheelwright
W. P. Wiltsee
R. P. Winton
Louis Yager

Committee

* Died June 10, 1941.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, including recommended revisions of Sections 302 (c) and 304 of the Specifications for Open-Hearth Steel Rails; revision of and additions to the Glossary, and revisions of the Instructions for Filling in Rail Failure Form 402–C and Instructions for Filling in Transverse Fissure Form 402–E ..... page 575

2. (a) Further research, including details of mill practice and manufacture as they affect rail quality and rail failures, giving special attention to transverse fissure failures and other defects in the head, web and base, collaborating with Rail Manufacturers' Technical Committee.

   Progress report, presenting Eighth Progress Report of the Rails Investigation with résumé of accomplishments to date and outline of work for 1942 ..... page 607

   (b) Specifications for thermal treatment of rail, such as control cooled, Brunorized, etc.

   Progress report, included in above Eighth Progress Report of the Rails Investigation ..... page 617

3. Compilation of statistics.

   (a) All rail failures, making special study of transverse fissure failures.

   Progress report, presented as information ..... pages 576, 582

   (b) Compilation of statistics for determining the performance of control cooled and Brunorized rail in service with respect to rail failures, with the view toward evaluating the higher price paid for treated than for untreated rails.

   Progress report, presented as information ..... page 588

4. Cause and prevention of rail battering and methods of reconditioning rail ends.
   Progress report, presented as information ..... page 591

5. Economic value of different sizes of rail.
   Progress report, presented as information ..... page 591

6. Continuous welding of rail, collaborating with Committee 5—Track.
   Progress report, presented as information ..... page 592

7. Service tests of various types of joint bars.
   Progress report, presented as information ..... page 592

8. Investigate joint bar failures and give consideration to the revision of design and specifications.
   Progress report, presented as information ..... page 602

9. Corrugated rail—causes and remedy. Effect upon riding qualities of tracks and upon the costs of track and equipment maintenance.
   Progress report, presented as information ..... page 603

10. Development and characteristics of fractures under engine burns in rail, together with investigation as to the effectiveness of welding up engine burns by oxy-acetylene or electric methods.
    Progress report, presented as information ..... page 605

The Committee on Rail,
W. H. Penfield, *Chairman.*

Grier Ralston Smiley

The Committee on Rail unanimously records the feeling of irreparable loss occasioned by the death on June 10, 1941, of a fellow member, Grier Ralston Smiley, chief engineer of the Louisville & Nashville Railroad.

Mr. Smiley was an active, conscientious and helpful worker on the committee, of which he was a member for five years. His election as a director of the Association in 1939 was a source of pride to his associates, who admired him for his many fine qualities of character.

Report on Assignment 1

Revision of Manual

C. B. Bronson (chairman, subcommittee), J. E. Armstrong, W. C. Barnes, N. J. Boughton, W. J. Burton, H. R. Clarke, J. L. Gressitt, G. W. Harris, E. M. Hastings, B. Herman, F. S. Hewes, Maro Johnson, W. H. Kirkbride, B. R. Kulp, G. M. Magee, E. E. Oviatt, W. H. Penfield, A. N. Reece, L. H. Scheifele, G. R. Smiley, Barton Wheelwright, Louis Yager.

Revision of Rail Specifications

Section 302 (c) of the Specifications for Open-Hearth Steel Rails provides for entering upon the test record for information only a Brinnel indentation upon the head of the three test specimens, the ball to be 19 millimeters in diameter and the pressure 100,000 pounds.

The Rail committee feels that this information is not of sufficient value to require that it be furnished and recommends eliminating it from the rail specifications.

Section 406 (c) provides for cutting a rail back to sound metal. The proposed revision provides for either cutting or breaking back to sound metal as well as providing for proper classification.

The revision of Section 406 (c) would then read as follows:

(c) When any finished rail shows conditions as described in Section 303 at either end or at any drilled hole it shall be cut or broken back to sound metal and accepted as a No. 1 or No. 2 short rail, subject to the requirements of Sections 304 and 402. If cut back, a fracture specimen shall be furnished the inspector to determine the interior condition.

The second item under Section 304 would also be changed to read as follows:

X-Rayls.

Rails as described in Section 303.

Revisions and Additions to Definitions

Some of the definitions in the Glossary covering rail defects needed clarifying to aid in more accurate reporting and classifying. The revisions cover Transverse Fissures, Horizontal Split Heads, Compound Fissures, and Detail Fractures. A definition has also been added for Engine Burn Fractures. The revisions and additions are as follows:

Transverse Fissure.—A progressive crosswise fracture starting from a crystalline center or nucleus *inside* the head from which it spreads outward as a smooth, bright or dark, round or oval surface substantially at a right angle to the length of the rail. The distinguishing features of a transverse fissure from other types of fractures or defects are the crystalline center or nucleus and the nearly smooth surface of the development which surrounds it. *4*

Horizontal Split Head.—A horizontal progressive defect originating *inside* of the rail head, usually ¼ inch or more below the running surface and progressing horizontally in all directions, and generally accompanied by a flat spot on the running surface. The defect appears as a crack lengthwise of the rail when it reaches the side of the rail head. (See Compound Fissures.) *4*

Compound Fissure.—A progressive fracture originating in a horizontal split head which turns up or down in the head of the rail as a smooth, bright or dark surface, progressing until substantially at a right angle to the length of the rail. Compound fissures require examination of both faces of the fracture to locate the horizontal split head from which they originate. *4*

Detail Fracture.—A progressive fracture originating at or near the surface of the rail head. These fractures should not be confused with transverse fissures, compound fissures, or other defects which have internal origins. Detail fractures are divided into the following types:

(1) Shelly spots where small shell-like pieces become detached from the top surface or sides of the rail head.

(2) Head Checks. Usually at or close to the gage corner where movement or flow of surface metal is sufficient to start a hairline crack. *4*

Engine Burn Fracture.—A progressive fracture originating in spots where driving wheels have slipped on top of the rail head. In developing downward they frequently resemble the compound or even transverse fissure with which they should not be confused or classified. *4*

The above revisions and additions would likewise apply to the reverse side of Form 402–A—Report of Rail Failures in Main Track.

Rail Record Forms

It is likewise essential to revise and broaden the instructions for reporting and recording failures in track, transverse fissures, and other rail failures, which are as follows:

FORM 402–C (a), page 4–47, Instruction 2:

2. It is desired to confine the statistics to failures which are attributable to faulty or defective metal. Hence failures which are primarily due to service conditions should not be reported. Therefore do not report rails broken or damaged by wrecks, broken wheels or similar causes; battered or chipped ends; those replaced on account of wear; rails repaired by welding; or rails which failed due to detail fractures, engine burn fractures, or injuries from other external causes.

FORM 402–E (a), page 4–50, Instruction 1:

2. Report is desired on all transverse fissures in rail weighing 80 pounds per yard and over, laid in all main track. True internal transverse fissure failures only (i.e., transverse fissures starting from a crystalline center or nucleus within the rail head) are to be reported. Compound fissures and horizontal split heads (sometimes called horizontal fissures) are to be reported on Form 402–C only. Detail fractures and engine burn fractures are likewise not to be reported on transverse fissure Form 402–E.

Report on Assignment 3 (a)

Rail Failure Statistics

Part 1—General Rail Failures

By W. C. Barnes
Engineer of Tests, Rail Committee

The rail failure statistics for the year ended December 31, 1940, appearing in this report, have been compiled in accordance with the standard method of basing the failure rates on mile-years of service in track.

The reported tonnages and track miles of rollings for 1935 and succeeding years, included in these statistics, are given at the top of the next page. These figures compare

(text continued on page 580)

Tonnages of Rail and Miles of Track Represented in the Statistics

Year Rolled	*Tons*	*Track Miles*
1935	377,637	2076
1936	743,911	4049
1937	840,878	4571
1938	378,553	2098
1939	703,545	3755
Total	3,044,524	16,549

TABLE I - AVERAGE FAILURES FOR 100 TRACK MILES - ALL MILLS
(Both service and detected failures are included)

Year Rolled	YEARS SERVICE				
	1	2	3	4	5
1908					398.1
1909				224.1	277.8
1910			124.0	152.7	198.5
1911		77.0	104.4	133.3	176.3
1912	28.9	32.1	49.3	78.9	107.1
1913	12.5	25.8	44.8	69.5	91.9
1914	8.2	19.8	32.9	50.9	74.0
1915	8.9	19.0	34.2	53.0	82.4
1916	11.8	29.2	47.7	70.6	105.4
1917	21.6	38.9	66.0	110.5	137.8
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.9	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	110.0
1923	14.3	33.2	57.6	86.0	114.1
1924	14.0	33.4	58.3	82.0	110.7
1925	15.5	35.6	58.3	76.6	110.7
1926	17.1	41.2	64.6	102.6	131.3
1927	18.4	37.7	69.5	94.6	112.4
1928	11.0	28.0	45.8	57.4	76.4
1929	14.1	36.8	55.9	82.7	121.2
1930	7.8	12.8	22.4	37.6	60.0
1931	9.1	19.7	32.3	46.8	67.4
1932	4.5	11.8	21.2	39.6	64.1
1933	6.2	11.7	25.6	52.4	73.5
1934	4.6	13.6	19.3	25.9	35.8
1935	4.2	9.6	16.3	32.3	51.0
1936	4.2	7.3	18.1	30.6	
1937	3.3	5.8	11.3		
1938	2.2	5.2			
1939	2.6				

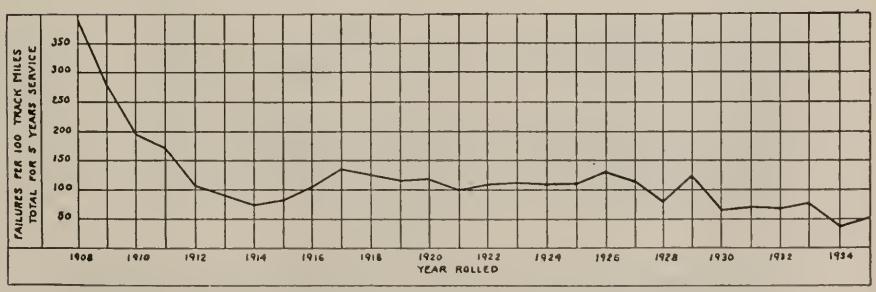


Fig. 1.—Service and Detected Rail Failures in the United States and Canada (5 Years' Service).

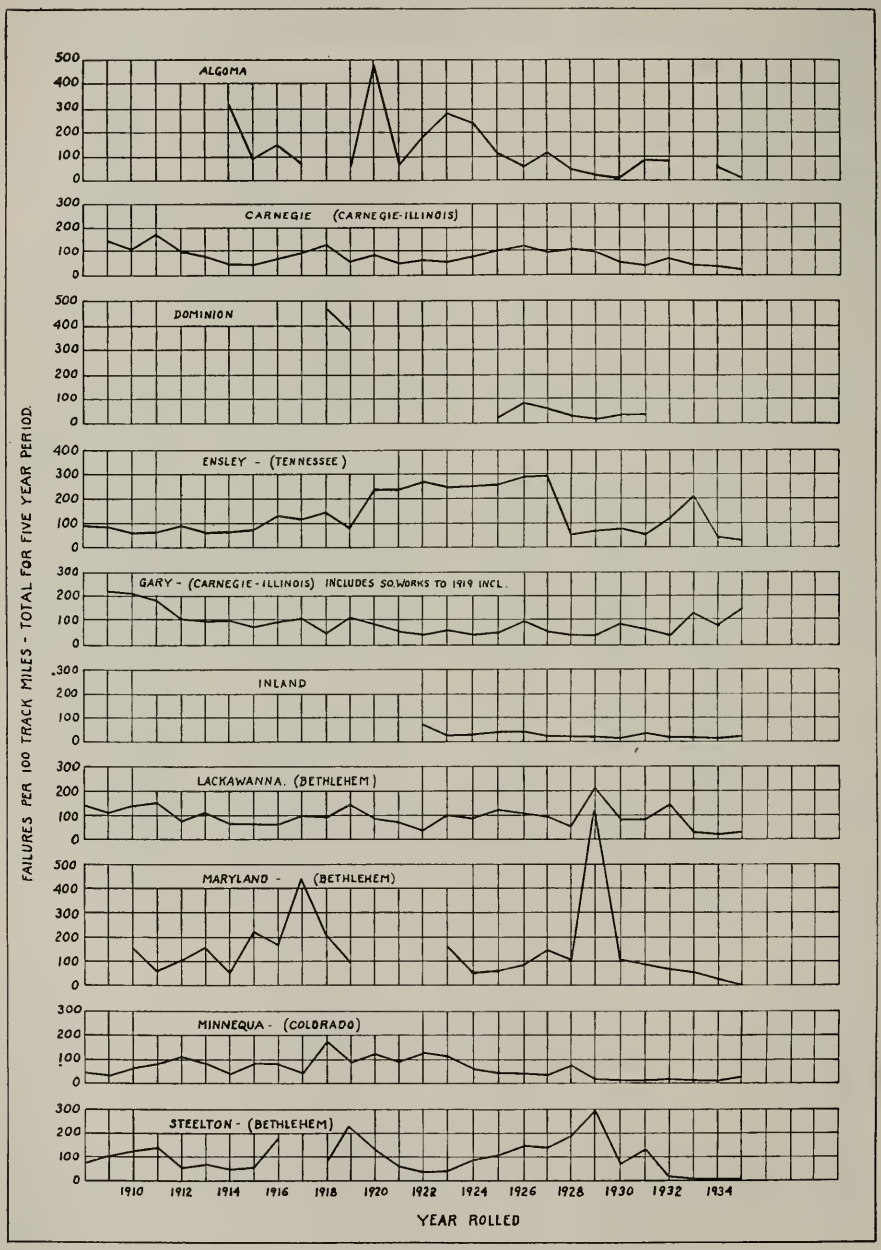


Fig. 2.—Record of Failures Per 100 Track Miles for Five Years' Service for Rollings from 1908 to 1935 (Service and Detected Failures Included).

MILL	YEAR ROLLED	FAILURES, ALL TYPES PER 100 TRACK MILE-YEARS: SERVICE ONLY	SERVICE AND DETECTED
CARNEGIE (CARNEGIE-ILLINOIS)	1935	2.7	4.4
	1936	3.9	5.0
	1937	5.5	5.8
	1938	4.6	6.0
	1939	3.6	3.6
ENSLEY (TENNESSEE)	1935	4.3	5.9
	1936	3.1	5.9
	1937	2.5	3.0
	1938	3.8	4.1
	1939	4.6	4.6
GARY (CARNEGIE-ILLINOIS)	1935	9.0	28.6
	1936	6.2	16.9
	1937	4.6	5.9
	1938	2.9	3.2
	1939	0.8	0.8
INLAND	1935	2.7	4.1
	1936	2.5	2.9
	1937	3.0	3.2
	1938	1.0	1.0
	1939	1.3	1.6
LACKAWANNA (BETHLEHEM)	1935	5.5	6.8
	1936	3.2	4.0
	1937	1.3	1.7
	1938	0.4	0.4
	1939	0.5	0.5
MARYLAND (BETHLEHEM)	1935	0.0	0.0
	1936	0.0	0.0
	1937	1.9	1.9
	1938	0.5	0.5
	1939	0.0	0.0
MINNEQUA (COLORADO)	1935	2.8	4.8
	1936	2.6	2.6
	1937	1.7	1.7
	1938	1.7	1.7
	1939	0.7	0.7
STEELTON (BETHLEHEM)	1935	1.5	1.6
	1936	0.7	1.1
	1937	2.3	2.7
	1938	0.2	0.2
	1939	2.5	2.6
ALL MILLS	1935	4.7	14.3
	1936	5.7	6.3
	1937	3.9	5.6
	1938	3.1	3.5
	1939	3.1	3.2

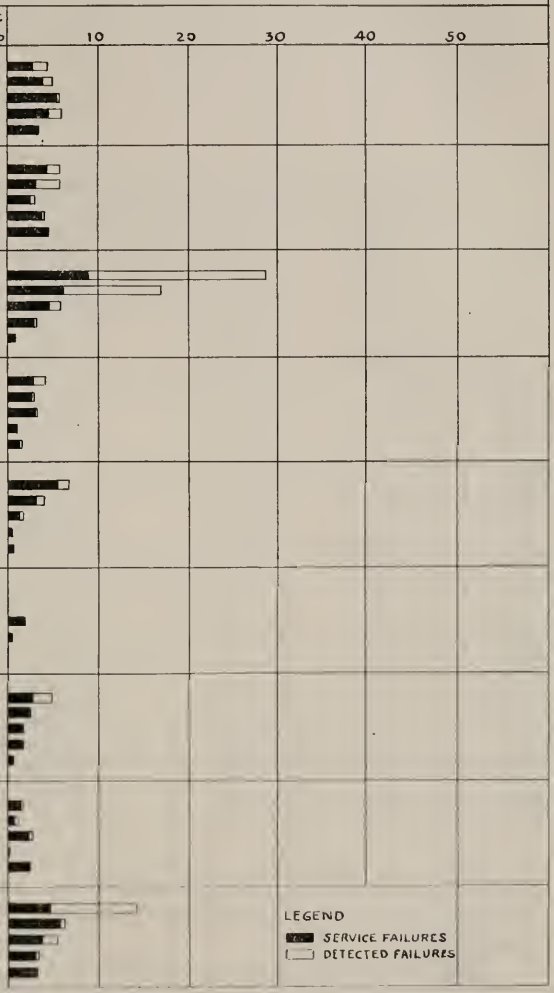


Fig. 3.—Failure Rates From Date Rolled to December 31, 1940, by Mills (Service and Detected Failure Rates Shown Separately).

(text continued from page 576)

with totals of 2,931,342 tons, or 16,006 track miles, of rail reported last year for the 1934 to 1938 rollings. Table 1 shows the average number of failures per 100 track miles of rail in service which accumulated during the one to five years' service in the rail reported from rollings of 1935 to 1939, inclusive, from all mills, together with similar rates of older rollings reproduced from previous reports. Both service and detected failures in all kinds of steel are included in this table.

The 1935 rollings whose period of observation is now concluded, show an average of 51.0 failures per 100 track miles for the five year period. This rate compares favor-

TABLE 2.- ACCUMULATED FAILURES AND FAILURE RATES FROM DATE ROLLED TO DEC. 31, 1940, BY MILLS, COMPUTED BY MILE YEARS OF RAIL IN SERVICE. ORIGINAL TRACK MILES ARE INCLUDED FOR INFORMATION ONLY.

Year Rolled	Orig'l Trk.Mls.	SERVICE Total	SERVICE Pr.100 Trk.Ml.Yrs.	SERVICE & DETECTED Total	SERVICE & DETECTED Pr.100 Trk.Ml.Yrs.	SERVICE & DETECTED Pr.100 Trk.Mls.	Orig'l Trk.Mls.	SERVICE Total	SERVICE Pr.100 Trk.Ml.Yrs.	SERVICE & DETECTED Total	SERVICE & DETECTED Pr.100 Trk.Ml.Yrs.	SERVICE & DETECTED Pr.100 Trk.Mls.
	ALGOMA						DOMINION					
1935	117.1	9	1.61	10	1.78	8.90	0.0	0	0	0	0	0
1936	119.5	22	5.92	23	6.20		41.1	0	0	0	0	
1937	128.0	14	4.06	15	4.35		42.5	0	0	0	0	
1938	105.3	3	1.44	4	1.92		45.6	0	0	0	0	
1939	96.1	1	1.04	1	1.04		26.0	0	0	0	0	
	CARNEGIE						ENSLEY					
1935	255.3	34	2.67	56	4.40	22.00	477.0	98	4.26	136	5.91	29.55
1936	465.6	70	3.89	90	5.00		600.9	73	3.12	137	5.85	
1937	600.7	86	5.46	91	5.78		690.2	52	2.52	61	2.97	
1938	189.5	16	4.58	17	5.96		456.0	34	3.75	37	4.08	
1939	342.6	9	3.55	9	3.55		519.5	24	4.64	24	4.64	
	GARY						INLAND					
1935	498.8	212	9.03	671	28.60	143.00	171.5	22	2.71	33	4.07	20.35
1936	1210.9	282	6.21	767	16.90		422.4	40	2.48	47	2.91	
1937	1187.0	159	4.55	200	5.89		389.3	34	3.02	36	3.20	
1938	498.2	28	2.91	31	3.22		151.2	3	.96	3	.96	
1939	1110.9	8	.78	8	.78		358.0	4	1.27	5	1.59	
	LACKAWANNA						MARYLAND					
1935	106.7	29	5.49	36	6.82	34.10	18.3	0	0	0	0	0
1936	191.0	24	3.17	30	3.96		41.3	0	0	0	0	
1937	303.2	12	1.32	15	1.65		103.4	5	1.87	5	1.87	
1938	134.8	1	.38	1	.38		88.0	9	.51	9	.51	
1939	209.2	1	.50	1	.50		35.1	0	0	0	0	
	MINNEQUA						STEELTON					
1935	295.9	41	2.83	70	4.82	24.10	135.1	10	1.49	11	1.64	8.20
1936	622.5	59	2.63	59	2.63		333.9	9	.72	14	1.11	
1937	746.4	34	1.66	34	1.66		380.8	25	2.33	29	2.71	
1938	60.0	2	1.71	2	1.71		369.2	1	.15	1	.15	
1939	761.4	39	.66	39	.66		296.0	0	0	0	0	
	ALL MILLS (Excl. Alg.& Dom.)						ALL MILLS (Incl. Alg. & Dom.)					
1935	1958.6	446	4.71	1013	10.70	53.50	2075.7	455	4.54	1023	10.20	51.00
1936	3888.5	557	3.79	1144	7.80		4049.1	579	3.80	1167	7.64	30.56
1937	4401.0	407	3.27	471	3.78		4571.5	421	3.26	486	3.76	11.28
1938	1946.9	94	2.49	101	2.67		2098.0	97	2.38	105	2.58	5.16
1939	3632.7	85	2.66	86	2.69		3754.8	86	2.59	87	2.62	2.62
TOTALS	15827.7	1589		2815			16549.1	1638		2868		

ably with those of earlier rollings with the single exception of the 1934 rollings which had the record low rate of 35.8. Fig. 1 shows the five year averages from Table 1 diagrammatically.

Table 2 presents the accumulated failures and failure rates of rail from each of the mills, for each of the rollings of 1935 to 1939, inclusive. Service and service-plus-detected failures and rates are shown separately. Fig. 2 shows diagrammatically the failure rates per 100 average track miles of the 1935 and earlier rollings for five years' service, from Table 2, for combined service and detected failures. Fig. 3 shows diagrammatically the Table 2 failure rates per 100 track mile years, separately for service and service-plus-detected failures, for each of the 1935 and subsequent rollings, by mills, unweighted for traffic.

Fig. 4 shows diagrammatically the comparative performance of the various mills from data underlying Fig. 3, except that traffic density factors have been introduced in

MILL	YEAR ROLLED	FAILURES, ALL TYPES, PER 100 TRACK MILE-YEARS, PER UNIT OF TRAFFIC DENSITY	
		SERVICE ONLY	SERVICE AND DETECTED
CARNEGIE (CARNEGIE-ILLINOIS)	1935	0.4	0.7
	1936	0.8	1.1
	1937	1.2	1.3
	1938	0.9	1.1
	1939	0.8	0.8
ENSLEY (TENNESSEE)	1935	3.7	5.1
	1936	2.5	4.7
	1937	2.0	2.4
	1938	3.2	3.4
	1939	3.6	3.6
GARY (CARNEGIE-ILLINOIS)	1935	4.9	15.5
	1936	3.7	10.0
	1937	2.4	3.0
	1938	1.4	1.5
	1939	0.4	0.4
INLAND	1935	1.1	1.7
	1936	1.2	1.4
	1937	1.3	1.4
	1938	0.4	0.4
	1939	0.6	0.8
LACKAWANNA (BETHLEHEM)	1935	2.5	3.1
	1936	1.5	1.9
	1937	0.6	0.8
	1938	0.2	0.2
	1939	0.3	0.3
MARYLAND (BETHLEHEM)	1935	0.0	0.0
	1936	0.0	0.0
	1937	0.6	0.6
	1938	0.3	0.3
	1939	0.0	0.0
MINNEQUA (COLORADO)	1935	2.6	4.4
	1936	2.6	2.6
	1937	1.7	1.7
	1938	1.7	1.7
	1939	0.7	0.7
STEELTON (BETHLEHEM)	1935	0.3	0.3
	1936	0.2	0.3
	1937	0.8	0.9
	1938	0.1	0.1
	1939	0.0	0.0
ALL MILLS	1935	1.8	4.3
	1936	1.8	3.7
	1937	1.5	1.8
	1938	1.2	1.2
	1939	1.1	1.1

Fig. 4.—Failure Rates From Year Rolled to December 31, 1940, by Mills, Altered by Traffic Density Factors (Service and Detected Failure Rates Shown Separately).

Table 3 Average Weights of Rail Compiled from Tonnages Used in This Report

Mill	1935	1936	1937	1938	1939
Algoma	106.8	105.7	106.0	101.7	106.3
Dominion	-	99.2	99.9	100.0	100.0
Edgar Thomson (Carn)	128.6	124.4	128.6	125.4	127.8
Ensley (Tenn)	107.0	108.1	108.2	108.0	114.0
Gary (Ill)	115.0	116.9	116.4	117.6	125.3
Inland	118.9	118.7	117.0	115.5	120.3
Lackawanna (Beth)	119.1	119.2	121.2	118.0	112.4
Maryland (Beth)	126.0	127.0	130.5	117.4	131.0
Minnequa (Colo)	117.1	115.8	111.4	120.9	120.4
Steelton (Beth)	122.9	123.7	126.1	119.0	123.3
ALL MILLS	115.7	105.5	116.9	115.0	119.2

the final computations, using the method described on pages 369–370 of Vol. 32, AREA Proceedings for 1931. This method is an approximation only. Table 3 shows the average weights of rail from the various mills and from all mills which are included in these statistics.

Report on Assignment 3 (a)

Rail Failure Statistics

Part 2—Transverse Fissure Failures

By W. C. Barnes
Engineer of Tests, Rail Committee

These statistics constitute a cumulative record of transverse fissure failures that have been reported up to and including December 31, 1940. They include all transverse fissured rails reported, whether located by actual breakage in service or detected before actual breakage by inspection or test. The totals shown, however, do not represent all such failures that have occurred for the reason that a few roads do not report their failures to the Association.

Every endeavor is being made, by instructions issued to the roads, to restrict the reporting of failures to those caused by transverse fissures. However, owing to the very close resemblance that exists between some transverse fissures and certain other types of progressive fractures which originate at the surface of the rail instead of in the interior, reports made by the railroads, and hence these statistics, no doubt include some progressive fracture failures which are not transverse fissure failures.

Table 1 corresponds with Table 1 of the report of last year, and shows separately the number of service and detected transverse fissure rail failures which have been reported in all rollings, no matter how old, classified by roads and by years in which the failures occurred. It includes data from roads which are consistently reporting the

TABLE 1.—TRANSVERSE FISSURE FAILURES BY RAILROAD AND BY YEAR FAILED—ALL ROLLINGS.

	SERVICE FAILURES											DETECTED FAILURES										
Yr. Failed	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	Total	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	Total
AT&SF	114	84	64	46	35	46	92	43	85	111	720	0	0	13	77	121	59	247	194	326	377	1,414
ACL	29	37	15	33	48	62	102	66	67	114	573	0	0	69	0	0	159	180	251	141	118	918
Ban. & Aroos	2	1	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
B & M	22	33	17	24	18	12	14	28	25	11	204	0	19	45	17	0	241	207	45	706	927	2,207
B & O	506	383	397	328	356	325	431	382	282	341	3,731	0	182	217	308	618	630	652	807	431	609	4,454
C. P.	109	90	103	113	121	134	138	114	164	225	1,311	351	214	372	834	899	999	1,501	1,239	1,780	2,011	10,300
C. of Ga.	42	74	56	81	54	64	55	59	70	77	632	0	107	18	136	101	96	119	110	91	130	908
C. of NJ	59	40	61	85	58	110	112	90	69	87	771	111	0	0	0	0	0	0	0	0	0	111
C & El	18	28	39	23	14	18	22	23	15	15	215	59	0	74	43	65	29	65	77	89	96	597
C & O	239	330	280	316	300	227	310	187	145	93	2,427	667	323	978	584	1,262	1,392	891	923	786	533	8,339
C & NW	86	110	81	99	69	68	41	38	47	62	701	110	218	110	341	155	355	317	294	465	631	2,996
CMSt.P&P	45	105	125	99	71	74	53	46	45	73	736	49	0	156	179	247	197	357	288	285	311	2,069
CRI&P	116	131	139	136	97	135	121	98	74	91	1,138	18	93	13	274	62	132	344	366	336	269	1,907
DL&W	64	102	82	65	76	90	75	72	72	56	754	0	0	0	173	244	229	454	461	400	140	2,101
Erie	175	181	179	187	171	167	229	123	133	110	1,655	4	0	75	0	165	0	166	264	350	238	1,262
GN	141	126	128	143	179	246	276	215	246	232	1,932	0	0	6	144	114	88	69	92	142	171	826
IC	310	281	245	275	364	467	540	515	520	474	3,991	204	217	273	108	284	314	447	557	596	727	3,727
IHB	0	0	0	0	3	2	6	0	0	0	11	0	0	0	0	0	0	0	2	0	0	2
L&HR	11	3	4	2	0	1	5	6	8	11	51	0	0	0	0	0	0	0	0	0	22	22
L&NE	6	3	2	7	0	0	6	1	5	4	34	0	0	0	16	0	0	24	0	0	26	66
L. V.	22	17	34	30	31	22	28	52	41	30	307	78	0	0	140	0	140	0	0	218	6	582
L&N	268	220	182	215	181	253	229	178	178	130	2,034	0	0	358	19	341	488	577	530	408	530	3,251
MKT	32	30	17	20	33	39	30	35	80	66	382	29	76	31	98	74	77	167	169	61	132	914
M&O	32	42	24	25	28	45	76	55	83	62	472	0	0	0	1	0	0	0	0	0	0	1
NC&StL	50	42	58	20	19	50	36	19	30	35	359	0	0	0	40	45	17	42	70	42	115	371
NYC.(Sys)	306	299	306	272	318	381	361	389	433	357	3,422	83	182	253	114	191	322	322	428	562	352	2,809
NYNH&H	25	24	40	59	34	37	48	39	31	28	365	159	106	101	100	82	60	101	92	110	58	969
NYO & W	48	54	67	34	34	21	37	55	33	20	403	1	4	0	0	0	0	0	0	0	0	5
N&W	41	29	50	33	23	38	36	22	21	10	303	0	5	0	74	0	0	84	45	44	53	305
N.P.	171	160	126	169	168	171	259	213	185	147	1,769	0	0	81	19	324	173	292	246	310	227	1,672
P.RR. (a)	426	345	345	430	414	544	672	513	442	323	4,454	576	403	851	440	1,073	690	757	857	920	1,158	7,725
P. M.	8	10	5	7	7	7	8	4	2	2	60	41	23	71	39	57	58	137	34	27	20	507
Reading	100	111	111	160	166	162	186	164	191	148	1,499	0	0	0	0	0	0	0	0	0	0	0
RF&P	1	3	5	4	4	2	4	3	2	5	33	0	0	36	0	67	44	53	52	61	37	350
Rutland	1	0	1	0	1	1	1	1	2	2	10	0	7	0	0	3	0	0	0	0	0	10
S.P. (PacLines)	331	322	269	208	200	324	481	394	590	347	3,466	251	142	374	580	455	767	629	637	477	709	5,021
Sou. (Sys)	183	160	187	232	261	368	504	256	226	258	2,635	0	0	0	0	0	0	0	1,263	1,061	1,101	3,425
U.P.	495	535	517	936	1,003	1,176	1,443	923	1,033	481	8,542	137	157	321	660	1,361	1,437	1,996	2,032	2,525	3,022	13,648
Virginian	24	24	28	33	30	23	36	34	39	30	301	0	0	0	0	0	0	0	0	0	126	126
W.Md.	148	94	94	62	87	116	70	133	50	53	907	0	0	0	106	0	0	86	0	72	82	346
All Roads	4,806	4,663	4,484	5,011	5,076	6,028	7,173	5,588	5,764	4,721	53,314	2,928	2,478	4,996	5,664	8,410	9,193	11,283	12,425	13,822	15,064	86,263

Note—(a) 1939 data revised to agree with supplementary report from Road.

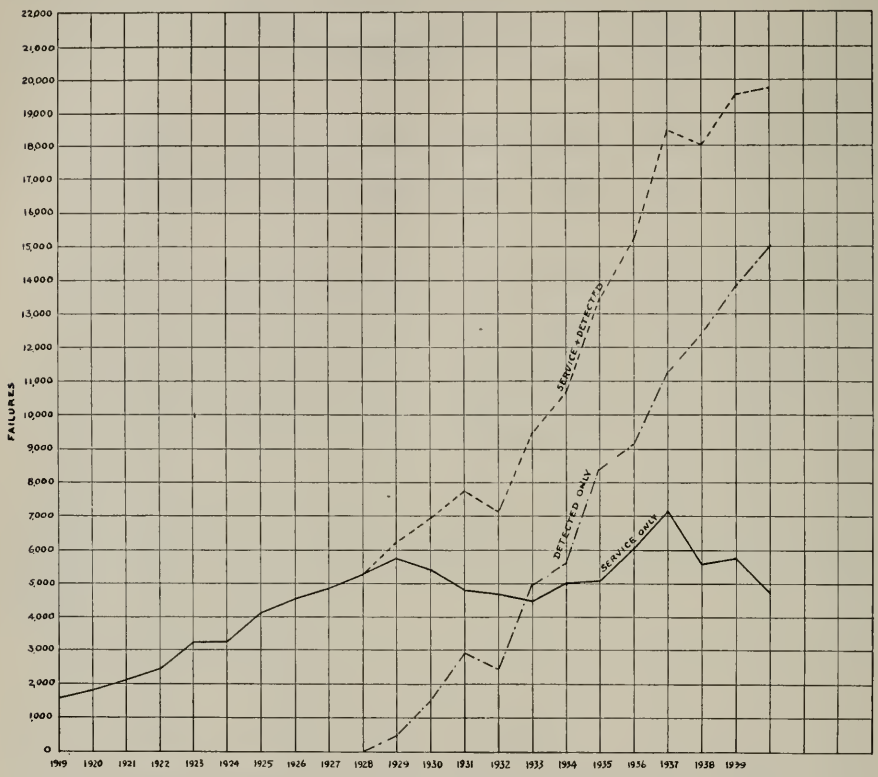


Fig. 1.—Total Fissure Failures Reported Each Year (1930 Includes 11 Months Only).

service and detected failures separately. The total transverse fissure failures which occurred on any one road or on all roads during any given year can be obtained by adding the corresponding figures for service failures and for detected failures appearing in this table.

The total fissure rail failures reported in 1940 compared with those in 1939 are:

	Service	*Detected*	*Total*
1940	4,721	15,064	19,785
1939	5,765	13,823	19,588
Increase in 1940	1,044 (decrease)	1,241	197

Fig. 1 presents graphically the fissure failures by year failed from Table 1. The solid curve shows the service failures; the broken line shows the detected failures and the dotted line shows the service-plus-detected failures. Table 2 shows all transverse fissure rail failures, including both service and detected failures, reported by all reporting roads, for the rollings of each year from 1931 to 1940 inclusive, from each mill, accumulated from the year rolled to December 31, 1940. These data are unweighted for tonnage out-

(text continued on page 588)

TABLE 2.—ACCUMULATED TRANSVERSE FISSURE FAILURES REPORTED FROM YEAR ROLLED TO DEC. 31, 1940 BY YEAR ROLLED AND BY MILL

(Includes Service and Detected Failures)

Year Rolled	Algoma			Carnegie			Colorado			Dominion		
	Prior	1940	Total	Prior	1940	Total	Prior	1940	Total	Prior	1940	Total
1931	39	14	53	208	48	256	43	31	74	1	1	2
32	56	58	114	104	18	122	11	18	29	0	0	0
33	0	0	0	50	10	60	0	2	2	0	0	0
34	49	54	103	22	14	36	3	3	6	0	0	0
35	0	0	0	11	4	15	9	7	16	0	0	0
36	0	0	0	4	3	7	2	5	7	0	0	0
37	0	0	0	1	2	3	1	0	1	0	0	0
38	0	0	0	2	1	3	0	1	1	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
Totals	144	126	270	402	100	502	69	67	136	1	1	2

TABLE 2.—ACCUMULATED TRANSVERSE FISSURE FAILURES REPORTED FROM YEAR ROLLED TO DEC. 31, 1940 BY YEAR ROLLED AND BY MILL—Continued

Year Rolled	Gary			Inland			Lackawanna			Maryland		
	Prior	1940	Total	Prior	1940	Total	Prior	1940	Total	Prior	1940	Total
1931	1,290	368	1,658	310	73	383	137	17	154	606	149	755
32	68	42	110	18	5	23	18	6	24	143	26	169
33	205	66	271	11	1	12	3	1	4	32	10	42
34	70	87	157	6	7	13	11	6	17	12	15	27
35	277	181	458	4	8	12	10	8	18	1	0	1
36	236	301	537	1	4	5	6	0	6	3	5	8
37	10	40	50	0	2	2	0	0	0	0	1	1
38	0	3	3	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
Totals	2,156	1,088	3,244	350	100	450	185	38	223	797	206	1,003

TABLE 2.—ACCUMULATED TRANSVERSE FISSURE FAILURES REPORTED FROM YEAR ROLLED TO DEC. 31, 1940 BY YEAR ROLLED AND BY MILL—Continued

Year Rolled	Steelton			Tennessee			All Mills		
	Prior	1940	Total	Prior	1940	Total	Prior	1940	Total
1931	711	96	807	952	285	1, 237	4, 297	1, 082	5, 379
32	19	3	22	468	135	603	905	311	1, 216
33	1	0	1	274	103	377	576	193	769
34	3	3	6	55	40	95	231	229	460
35	2	0	2	52	21	73	366	229	595
36	3	2	5	3	26	29	258	346	604
37	0	2	2	0	1	1	12	48	60
38	1	0	1	1	5	6	4	10	14
39	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0
Totals	740	106	846	1, 805	616	2, 421	6, 649	2, 448	9, 097

MILL	YEAR ROLLED	FISSURE FAILURE RATES PER 100 TRACK MILE-YEARS: SERVICE ONLY.	SERVICE AND DETECTED
CARNEGIE (CARNEGIE-ILLINOIS)	1931	1.7	7.9
	1932	3.1	6.1
	1933	1.6	3.9
	1934	0.4	0.8
	1935	0.3	1.2
	1936	0.2	0.4
	1937	0.1	0.2
	1938	0.0	0.0
	1939	0.0	0.0
ENSLEY (TENNESSEE)	1931	8.6	21.3
	1932	9.9	36.1
	1933	11.5	58.0
	1934	0.9	3.5
	1935	1.7	4.1
	1936	0.3	1.4
	1937	0.0	0.0
	1938	0.0	0.0
	1939	0.0	0.0
GARY (CARNEGIE-ILLINOIS)	1931	6.0	24.8
	1932	3.5	6.9
	1933	3.7	18.9
	1934	0.8	2.5
	1935	3.5	14.3
	1936	1.2	6.6
	1937	0.5	1.5
	1938	0.1	0.3
	1939	0.0	0.0
INLAND	1931	6.8	22.0
	1932	0.6	3.5
	1933	0.7	2.3
	1934	0.1	0.5
	1935	0.0	0.9
	1936	0.0	0.2
	1937	0.0	0.0
	1938	0.0	0.0
	1939	0.0	0.0
LACKAWANNA (BETHLEHEM)	1931	3.1	7.4
	1932	0.7	4.0
	1933	0.5	1.0
	1934	0.6	1.0
	1935	2.1	3.8
	1936	0.3	0.9
	1937	0.0	0.0
	1938	0.0	0.0
	1939	0.0	0.0
MARYLAND (BETHLEHEM)	1931	13.8	61.0
	1932	0.8	50.4
	1933	0.3	2.1
	1934	1.4	3.3
	1935	0.0	0.0
	1936	0.0	0.0
	1937	0.5	0.5
	1938	0.0	0.0
	1939	0.0	0.0
MINNEQUA (COLORADO)	1931	1.2	3.3
	1932	0.3	1.3
	1933	0.0	0.2
	1934	0.2	0.4
	1935	0.5	1.0
	1936	0.3	0.4
	1937	0.0	0.0
	1938	0.8	0.8
	1939	0.0	0.0
STEELTON (BETHLEHEM)	1931	10.1	21.9
	1932	2.1	7.3
	1933	0.0	0.4
	1934	0.2	0.3
	1935	0.4	0.6
	1936	0.2	0.5
	1937	0.1	0.2
	1938	0.2	0.2
	1939	0.0	0.0
ALL MILLS	1931	6.0	18.8
	1932	3.3	11.4
	1933	2.5	11.7
	1934	0.6	1.8
	1935	1.5	4.9
	1936	0.5	2.4
	1937	0.2	0.6
	1938	0.1	0.2
	1939	0.0	0.0

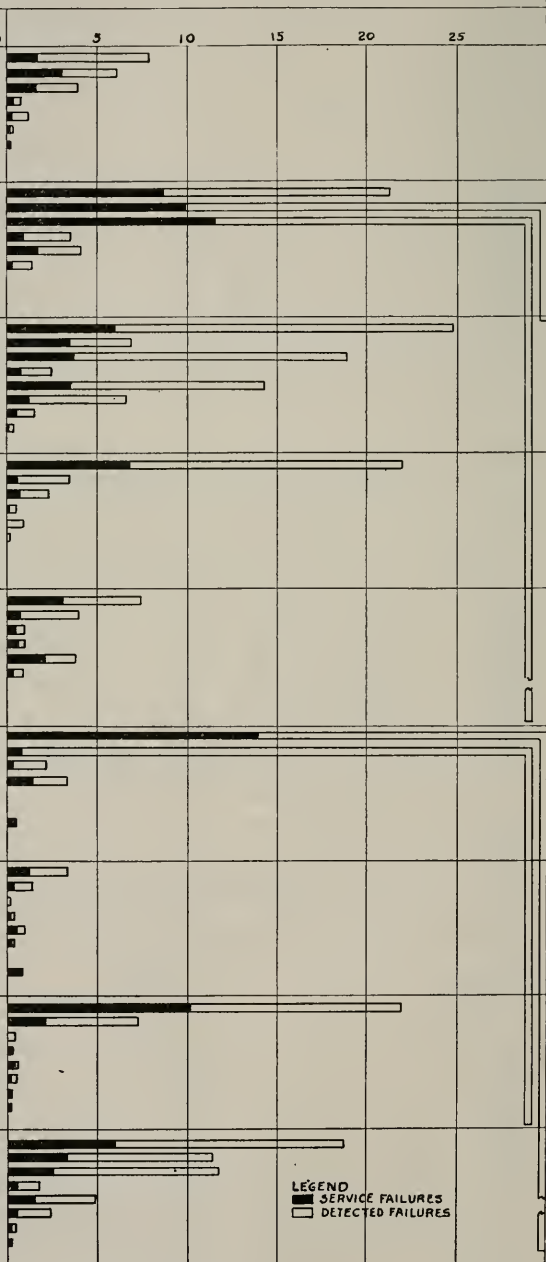


Fig. 2.—Fissure Failure Rates From Date Rolled to December 31, 1940, by Mills (Service and Detected Failures Shown Separately).

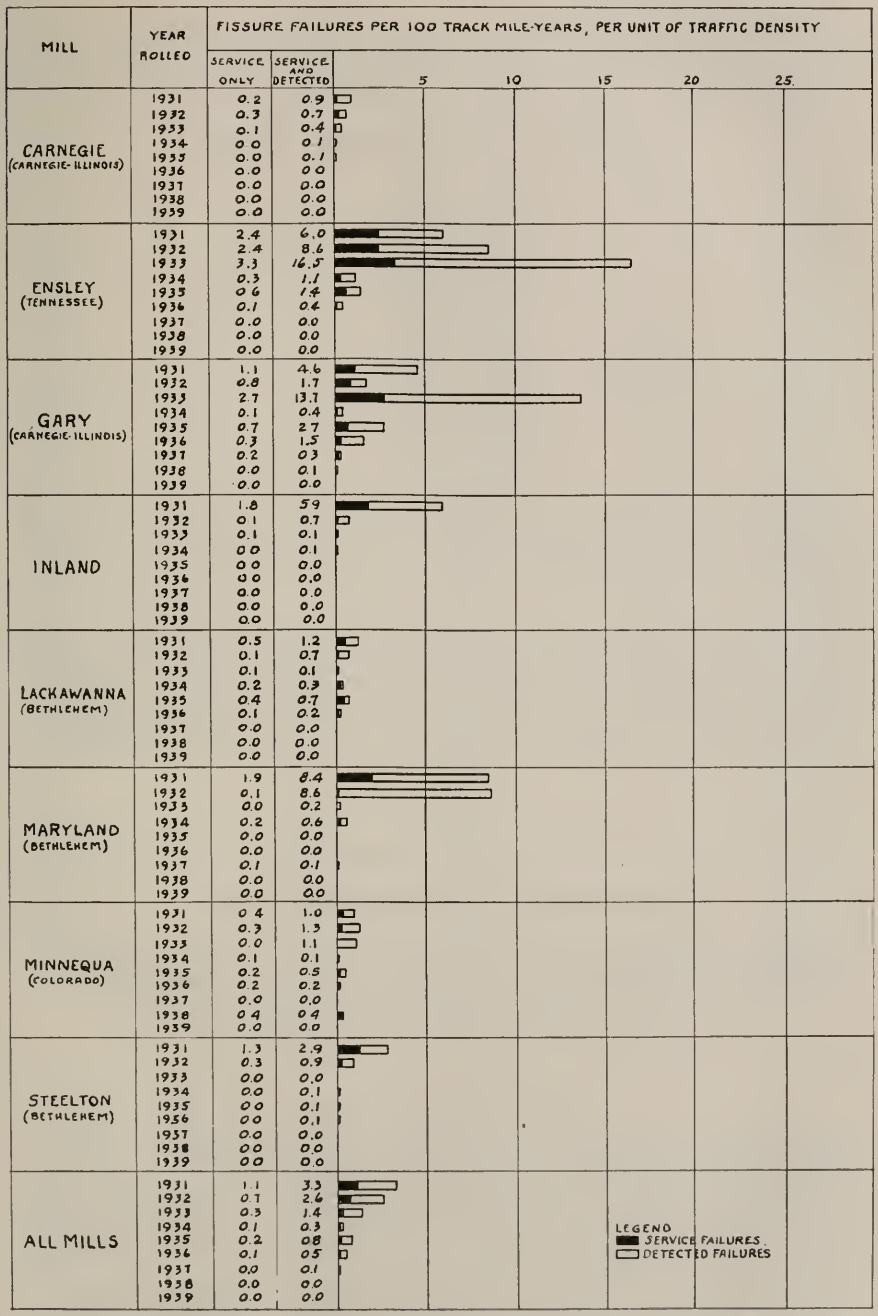


Fig. 3.—Fissure Failure Rates From Date Rolled to December 31, 1940, by Mills. Altered by Traffic Density Factors (Service and Detected Failures Shown Separately).

(text continued from page 584)

put of mills, density of traffic or for years in service. This table is most useful in comparing the failures which were reported in rollings of various years from any one mill.

Fissure rail failures reported since 1924, as occurring in the first year of service, are as follows:

29	Failures	in	1925	from	1925	Rollings,	All	Mills
50	"	"	1926	"	1926	"	"	"
114	"	"	1927	"	1927	"	"	"
58	"	"	1928	"	1928	"	"	"
106	"	"	1929	"	1929	"	"	"
33	"	"	1930	"	1930	"	"	"
32	"	"	1931	"	1931	"	"	"
3	"	"	1932	"	1932	"	"	"
0	"	"	1933	"	1933	"	"	"
0	"	"	1934	"	1934	"	"	"
3	"	"	1935	"	1935	"	"	"
3	"	"	1936	"	1936	"	"	"
1	"	"	1937	"	1937	"	"	"
0	"	"	1938	"	1938	"	"	"
0	"	"	1939	"	1939	"	"	"
0	"	"	1940	"	1940	"	"	"

Fig. 2 is a mill rating chart which shows separately, for each mill, the service and detected transverse fissure rail failure rates per 100 track mile years, from date of rolling to December 31, 1940, unweighted for traffic, for each of the rollings of 1931 to 1939, inclusive.

Fig. 3 shows graphically the average rates of failure, by mills, from Fig. 2, modified by the application of average traffic density factors, the derivation of which is explained on pages 369–70 of Vol. 32 of the AREA Proceedings for 1931. Owing to the necessity of using factors obtained from average traffic per mile of road, instead of actual traffic over the particular rails in question, this chart can be considered only as an approximation.

Report on Assignment 3 (b)

Controlled-Cooled and Brunorized Rail

Compilation of Statistics for Determining the Performance of Controlled-Cooled and Brunorized Rail in Service with Respect to Rail Failures, with the View Toward Evaluating the Higher Price Paid for Treated Than for Untreated Rails

By W. C. Barnes
Engineer of Tests, Rail Committee

Data are being accumulated to assist in determining the performance in service of controlled-cooled and Brunorized rail rolled under contract.

Controlled-cooled rail was first rolled under contract by the various mills as follows: Dominion—January, 1931; Algoma—December, 1933; Steelton—March, 1935; Inland—April, 1935; Lackawanna—May, 1935; Carnegie—October, 1935; Colorado—January, 1936; Ensley—February, 1936; Gary—April, 1936.

Brunorized rail was first rolled under contract at Gary by the old process in October, 1936. This process was revised on April 27, 1938, to provide for holding the rails

TABLE 1.—TONNAGE OF CONTROLLED-COOLED AND BRUNORIZED CONTRACT RAIL PURCHASED TO JUNE 30, 1941

Road	*Controlled-cooled*	*Brunorized*	*Total*
AT&SF	346,256	3,571	349,827
ACL	10,609	0	10,609
B&O	73,268	0	73,268
B&M	29,667	0	29,667
CPR	206,585	0	206,585
CNR	226,408	0	226,408
C&NW	84,992	19,572	104,564
C&O	211,496	0	211,496
CB&Q	135,178	21,260	156,438
CMStP&P	76,539	43,243	119,782
CRI&P	150,928	0	150,928
D&H	35,238	0	35,238
D&RGW	53,694	0	53,694
DL&W	43,383	0	43,383
ERIE	113,964	0	113,964
GN	72,244	21,454	93,698
IC	92,726	5,555	98,281
IRT Co.	16,615	0	16,615
KCS	17,853	7,777	25,630
LV	7,739	0	7,739
L&N	126,330	0	126,330
MKT	0	204	204
MP	151,644	0	151,644
MeCent.	6,297	0	6,297
NYC Sys.	261,472	13,117	274,589
NYC&StL	55,635	0	55,635
NYNH&H	55,059	0	55,059
N&W	89,159	0	89,159
NP	150,323	0	150,323
PM	34,224	0	34,224
PRR	291,843	0	291,843
READING	4,837	0	4,837
RF&P	10,425	0	10,425
SP	263,415	0	263,415
Sou.Sys.	123,796	0	123,796
UP	233,531	4,498	238,029
Total, Tons	3,863,372	140,251	4,003,623

at a temperature of 800–1,000 deg. F. for 2½ hours before charging them into the Brunorizing furnace.

Table 1 lists the tonnages of all such contract rail, from all mills, purchased by roads represented on the Rail committee as reported to June 30, 1941. It includes a total of 3,863,372 tons of controlled-cooled rail and 140,251 tons of Brunorized rail, making a total of 4,003,623 tons. This represents an increase of 841,166 tons of controlled-cooled rail and 16,378 tons of Brunorized rail over the tonnages reported purchased to June 30, 1940.

Table 2 lists failures that have been reported to November 17, 1941, in the rail listed in Table 1. These failures are classified in accordance with AREA standards. The few transverse and compound fissure failures in controlled-cooled rails which are listed

TABLE 2.—FAILURE DATA OF CONTROLLED-COOLED AND BRUNORIZED RAIL SUMMARY BY MILLS—ALL ROLLINGS

Accumulated Failures to November 17, 1941

Controlled-Cooled Rail

Mill	*Trans. Fiss.*	*Comp'd. Fiss.*	*Other Head*	*Broken*	*Web*	*Base*	*Total*
Algoma	0	0	73	15	12	84	184
Carnegie	1 (a)	0	10	7	20	3	41
Colorado	0	0	20	6	6	2	34
Dominion	0	0	57	8	33	17	115
Gary	3 (b,c)	0	22	19	11	21	76
Inland	1 (d)	2 (e)	18	43	10	16	90
Lackawanna	0	0	6	2	2	1	11
Steelton	2 (a)	1 (a)	17	13	7	2	42
Tennessee	1 (a)	1 (f)	90	23	90	9	213
All Mills—All Rollings	7	4	313	136	191	155	806
Brunorized Rail							
Gary (Old Process)	37	4	11	5	3	10	70
Gary (Revised Process)	0	0	0	0	0	0	0

(a) Developed from inclusions.
(b) Two rolled Dec. 1936 and March 1937, resulting from use of unsuitable cooling box covers.
(c) Started ⅞ in. below tread, where spot on rail had been welded up.
(d) Started from blow hole.
(e) One started from gage corner shelling, other from blow hole.
(f) Started under shelled gage corner.

have been verified, but investigation has shown that all but two developed from causes which the controlled-cooling process does not eliminate, namely: Inclusions, gas pockets and overloading. Investigation of the two which originated in shatter cracks developed the fact that these rails were rolled before suitable cooling box covers were in use. It will be noted that a number of fissures have developed in Brunorized rails which were rolled prior to the change made in that process in April, 1938. No fissures have been reported in any Brunorized rail made under the revised process. More detailed description of the origin of the above mentioned fissures will be found in foot notes to Table 2.

Report on Assignment 4

Cause and Prevention of Rail Battering and Methods of Reconditioning Rail Ends

F. M. Graham (chairman, subcommittee), W. C. Barnes, L. H. Bond, N. J. Boughton, C. B. Bronson, H. A. Cassil, H. R. Clarke, E. J. Cullen, W. A. Duff, P. O. Ferris, F. W. Gardiner, C. J. Geyer, E. M. Hastings, B. Herman, F. S. Hewes, W. H. Kirkbride, B. R. Kulp, G. M. Magee, R. W. Marye, Ray McBrian, C. E. Morgan, E. E. Oviatt, J. C. Patterson, W. H. Penfield, J. C. Ryan, L. H. Scheifele, R. T. Scholes, F. S. Schwinn, G. R. Smiley, A. N. Talbot, R. P. Winton.

This is a progress report, presented as information.

The subcommittee, with the "Rails Investigation" of the University of Illinois, is conducting the investigation of the field test of heat-treated rail ends on the Chesapeake & Ohio Railway, north of Carey, Ohio. This test is outlined in Appendix F of the 1940 report of Committee 4—Rail.

There have been no new developments in this test since the progress report of March, 1941.

The gross tonnage which moved over the test track since the beginning of the test to October 31, 1941, was 105,374,840 tons.

As reported last year a field test of various methods of welding employed by the railroads to build up rail ends has been undertaken in a stretch of the southbound track on the Richmond, Fredericksburg & Potomac Railroad, near Penola, Va. This stretch of track was divided into 11 panels of 50 joints each. One panel was assigned to each of 8 railroads, 2 panels to 1 railroad, and 1 panel to a contractor, with the understanding that each participant in the test would build up the rail ends in its assigned panel, using its own employees and the methods of building up rail ends employed on its own line.

The work was done in accordance with this plan during the week of May 5, 1941. The subcommittee had representatives present to record pertinent information, and will inspect this work from time to time and make a full report to the Association when the test has developed the necessary information.

Report on Assignment 5

Economic Value of Different Sizes of Rail

J. M. Farrin (chairman, subcommittee), W. T. Alexander, J. E. Armstrong, S. E. Armstrong, W. J. Backes, W. C. Barnes, C. B. Bronson, W. J. Burton, W. A. Duff, C. J. Geyer, J. L. Gressitt, G. W. Harris, E. M. Hastings, B. Herman, W. H. Hillis, W. H. Kirkbride, G. M. Magee, R. W. Marye, W. H. Penfield, Philip Petri, B. H. Prater, A. N. Reece, A. N. Talbot, Barton Wheelwright, W. P. Wiltsee, Louis Yager.

Additional information has been gathered during the past year with a view to checking ratios of the different sizes of rail which had previously been tentatively worked out, but before presenting a further report it is desired to give the subject more study. Therefore, the committee reports progress, with the recommendation that the subject be continued.

Report on Assignment 6

Continuous Welding of Rail

Collaborating with Committee 5—Track

J. C. Patterson (chairman, subcommittee), S. E. Armstrong, W. C. Barnes, C. B. Bronson, E. J. Cullen, J. M. Farrin, P. O. Ferris, C. J. Geyer, G. W. Harris, E. M. Hastings, G. M. Magee, R. W. Marye, C. E. Morgan, E. E. Oviatt, W. H. Penfield, G. A. Phillips, B. H. Prater, J. C. Ryan, R. T. Scholes, G. R. Smiley, R. P. Winton.

This report is submitted as information with the recommendation that the subject be continued.

Your committee reports additional service failures of continuous welded rail on six of the installations listed in the report published in the AREA Proceedings, Vol. 42, pages 660–662.

Railroad	*Location*	*Process*	*Date Installed*	*Failures Previously Reported*	*Failures This Report*	*Total Failures*
L. & N.	Vasper tunnel	"B" Gas Fusion	5–26–36	27	*	27
L. & N.	Kufa tunnel	"B" Gas Fusion	5–5–38		4	4
Southern	Alexandria, Va.	"B" Gas Fusion	9–1938	3	5	8
D. & H.	Schenectady, N. Y.	"C" Thermit, (Old Type)	1935	6	2	8
Erie	Otisville, N. Y.	"C" Thermit (Old Type)	1936	16	7	23
Denver & Salt Lake	Moffat tunnel	"C1" Thermit (Type K)	7–1938	7	1	8

* Rail removed January 1941.

A revised summary to date appears on the folded insert.

Report on Assignment 7

Service Tests of Various Types of Joint Bars

Ray McBrian (chairman, subcommittee), J. B. Akers, W. T. Alexander, W. J. Backes, W. C. Barnes, L. H. Bond, C. B. Bronson, W. J. Burton, H. A. Cassil, W. A. Duff, P. O. Ferris, F. M. Graham, F. S. Hewes, W. H. Kirkbride, B. R. Kulp, G. M. Magee, R. W. Marye, C. E. Morgan, W. H. Penfield, G. A. Phillips, B. H. Prater, J. C. Ryan, R. T. Scholes, A. N. Talbot, Barton Wheelwright.

As previously reported, the test joints were applied to 9 one-mile stretches of 112-lb. rail in the westbound track of the Atchison, Topeka & Santa Fe Railway west of Streator, Ill., in June 1937 and to 12 half-mile stretches of 131-lb. rail in the eastbound track of the Pennsylvania Railroad east of Valpariso, Ind., in August 1937. The south rail of both tracks had hardened rail ends. This is a report of further progress in this test and is presented as information.

Observations and measurements have been continued during 1941, the principle measurements including:

Process	
"A" Gas Fusion	
"B" Gas Fusion	
"C" Thermit (Old Type)	
"C1" Thermit (Type K)	
"D" Electric Pressure Weld	
"E" Gas Pressure Weld (Oxweld)	

* No speed restriction. [1]
[3] Removed January, 194

f
l.
e
n
e
e
-
-
s
e
d
t
s
e
-
n
e
n

Installations of Continuous Welded Rail—Summary to Date

Process	Length of Welded Rail: Road	Length of Welded Rail: Ft.	Number of Welded Joints	Weight of Rail Lb. per Yd	Bars Applied	Maximum Wheel Load Lb.	Annual Tonnage	Traffic: Pass.	Traffic: Frt.	Speed M. P. H.	Date Installed	In Tunnel or Open	Failures
"A" Gas Fusion	(M. P.)	3, 510	180	90	Yes	32, 150	2, 700, 000	Pass.	Frt.	30	1937	Tunnel	None
	(M. P.)	2, 808	144	90	Yes	32, 150	2, 700, 000	"	"	30	1938	"	"
	(M. P.)	2, 691	138	90	Yes	32, 150	2, 700, 000	"	"	30	1938	"	"
	(M. P.)	585	31	90	Yes	32, 150	2, 700, 000	"	"	50	1938	"	"
	(M. P.)	1, 053	54	90	Yes	32, 150	2, 700, 000	"	"	50	1939	"	"
	(C. of Ga.)	2, 457[1]	126	90	Yes	32, 500	4, 500, 000	"	"	30	Sept. 1930	"	22
	(C. of Ga.)	1, 283[1]	66	90	Yes	32, 500	4, 500, 000	"	"	30	Aug. 1930	"	10
			739										32
	(C. of Ga.)	2, 563	131	112 RE	Yes	32, 500	4, 500, 000	"	"	30	April 1937	"	None
	(C. of Ga.)	1, 389	71	112 RE	Yes	32, 500	4, 500, 000	"	"	30	" 1937	"	"
			202										None
	(C. of Ga.)	2, 184	110	112 RE	Yes	32, 500	10, 740, 000	"	"	60	Oct. 1937	Open	None
	(G. N.)	1, 122[2]	32	131 RE	No	36, 000	13, 200, 000	"	"	60	Dec. 1939	Open	None
"B" Gas Fusion	(L. & N.)	1, 638[3]	82	100 RE	Yes	Not reported	15, 000, 000	"	"	60	May 1936	Tunnel	37+
	(L. & N.)	1, 014	52	100 RE	Yes	26, 250	8, 000, 000	"	"	40	May 1938	"	4
	(L. & N.)	2, 324	117	101. 49	Yes	26, 250	6, 721, 110	"	"	70	Feb. 1939	"	None
	(L. & N.)	1, 092	54	101. 49	Yes	26, 250	7, 147, 430	"	"	60	Feb. 1939	"	"
	(L. & N.)	747	38	100 RE	Yes	26, 250	8, 000, 000	"	"	40	April 1939	"	3
			343										44+
	(Sou. Ry.)	4, 125	162	100	Yes	31, 000	6, 000, 000		"	20	Sept. 1938	Open	8
"C" Thermit (Old Type)	(Erie)	5, 616	168	131 RE	No	36, 000	16, 500, 000		"	40	June 1936	Tunnel	23
	(N. P.)	3, 783	194	131 RE	No	37, 000	7, 000, 000	"	"	25	July 1936	"	3
	(N. P.)	4, 017	206	131 RE	No	37, 000	7, 000, 000	"	"	25	Aug. 1936	"	2
			668										28
	(B. & L. E.)	5, 280	269	131 RE	No	37, 900	9, 000, 000	"	"	55–35	Oct. 1935	Open	2
	(D. & H.)	2, 994	318	130 RE	No	26, 800	12, 104, 000	"	"	20	Aug. & Sept. 1933	Open	9
	(D. & H.)	2, 519	254	131 RE	No	40, 000	3, 000, 000	"	"	35	May 1934	"	1
	(D. & H.)	11, 787	551	131 RE	No	40, 000	9, 000, 000		"	*	June & Sept. 1935	"	8
	(D. & H.)	3, 089	281	131 RE	No	35, 900	6, 288, 241		"	20	1935	"	None
	(D. & H.)	4, 054	408	131 RE	No	33, 650	3, 714, 700	"	"	75	May & June 1936	"	"
	(D. & H.)	591	74	131 RE	No	33, 650	3, 567, 000	"	"	20	June 1936	"	"
			2, 165										20
"C1" Thermit (Type K)	(D. & S. L.)	34, 056	1, 052	112 RE	No	36, 500	Not reported	"	"	50	July 1938	Tunnel[4]	8
	(B. & O.)	1, 365	68	112 RE	No	32, 000	10, 000, 000	"	"	45	July 1939	"	None
	(B. & O.)	2, 145	108	112 RE	No	32, 000	10, 000, 000	"	"	45	July 1939	"	"
			1, 228										8
	(G. N.)	5, 668	290	110 RE	No	35, 000	6, 042, 000	"	"	55	1937	Open	1
	(D. & H.)	7, 018	1, 559	131 RE	No	35, 900	9, 172, 800		"	30	1937	Open	6
	(D. & H.)	2, 519	253	131 RE	No	34, 250	3, 000, 000	"	"	65	Sept. 1939	"	None
	(D. & H.)	6, 566	98	131 RE	No	33, 650	5, 353, 500	"	"	65–35	June–July 1937	"	2
	(D. & H.)	3, 168	65	131 RE	No	35, 900	11, 860, 409	"	"	60	1937	"	1
	(D. & H.)	4, 333	53	131 RE	No	33, 650	3, 567, 000	"	"	65	1937	"	None
	(D. & H.)	3, 273	47	131 RE	No	35, 900	16, 969, 738	"	"	60	1937	"	"
			2, 076										9
"D" Electric Pressure Weld	(Erie)	5, 540	282	131 RE	No	36, 000	10, 350, 000		"	40	Oct. 1939	Tunnel	None
	(D. & H.)	11, 787	70	131 RE	No	40, 000	9, 000, 000		"	*	June–Sept. 1935	Open	2
	(D. & H.)	5, 953	874	131 RE	No	35, 900	9, 172, 800	"	"	30	1937	"	None
	(D. & H.)	6, 566	1, 987	131 RE	No	33, 650	5, 353, 500	"	"	65–35	June–July 1937	"	1
	(D. & H.)	4, 333	1, 622	131 RE	No	33, 650	3, 567, 000	"	"	65	1937	"	None
	(D. & H.)	3, 273	513	131 RE	No	35, 900	16, 969, 738	"	"	60	1937	"	"
	(D. & H.)	3, 168	1, 142	131 RE	No	35, 900	11, 860, 409	"	"	60	1937	"	1
	(D. & H.)	1, 401	1, 069	131 RE	No	33, 650	6, 353, 500	"	"	65	May 1939	"	None
			7, 277										4
"E" Gas Pressure Weld (Oxweld)	(C. G. W.)	2, 640	257	112 RE	No	30, 500	8, 000, 000	"	"	60	May 1939	Open	4
	(C. & I. M.)	933	131	112 RE	No	32, 400	7, 000, 000	"	"	15	July 1939	"	None
			388										4

* No speed restriction. [1] Removed April, 1937. [2] Normalized by controlled cooling.
[3] Removed January, 1941. [4] Moffat Tunnel.

(a) Joint camber on rail head;
(b) Rail surface profile;
(c) Out-to-out distance of bars;
(d) Bolt tension on the A. T. & S. F. Ry.

Joint Camber

A method of judging the surface conditions of rail joints for the various types of bars is the joint camber in a chord length of 34½ in. on the running surface of the rail. The joint camber depends on the wear, batter and flow of the rail, on the droop of the joint, on the camber of the bars themselves and on the amount the bars have been pulled in, especially if the bars have become worn. The data show that most of the present decrease in camber is due to batter and only a small amount to droop of the joint. In Fig. 1 are plotted average values for 30 consecutive joints on the controlled-cooled, non-end-hardened north rail and also for 30 joints on the Brunorized and end-hardened south rail for each of the 9 test stretches on the Santa Fe track for the years 1937, 1938, 1939 and 1941. In the figure two points are plotted and connected by a line for each type of joint on each rail, giving the camber at ½ in. from the leaving rail end and ½ in. from the receiving rail end for a chord of 34½ in., the left point and right point respectively on the figure. A point above the zero line in the diagram indicates that the rail end is higher than the rail surfaces back 17 in.; if below the zero line, the point is lower. For the north rail there has been a noticeable lowering in the joint camber; in 1941 all the points are below the zero line. The AREA 24-in. wedge joints on mile 98–99 and the AREA 24-in. full bearing joints on mile 103–104 show more decrease than for the other stretches. Quite a few of the individual joints on the north rail in

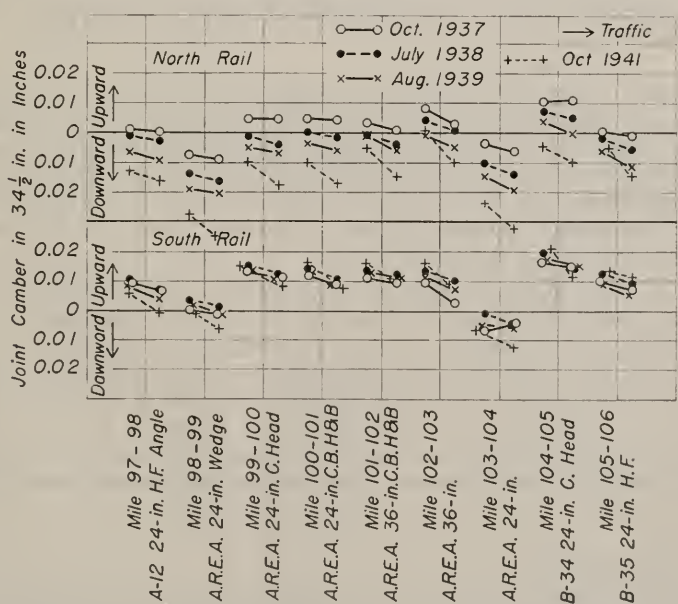


Fig. 1.—Joint Camber in 34½ in. at Leaving and Receiving Rail Ends for 60 Joints in Each Test Stretch on Santa Fe in 1937, 1938, 1939 and 1941.

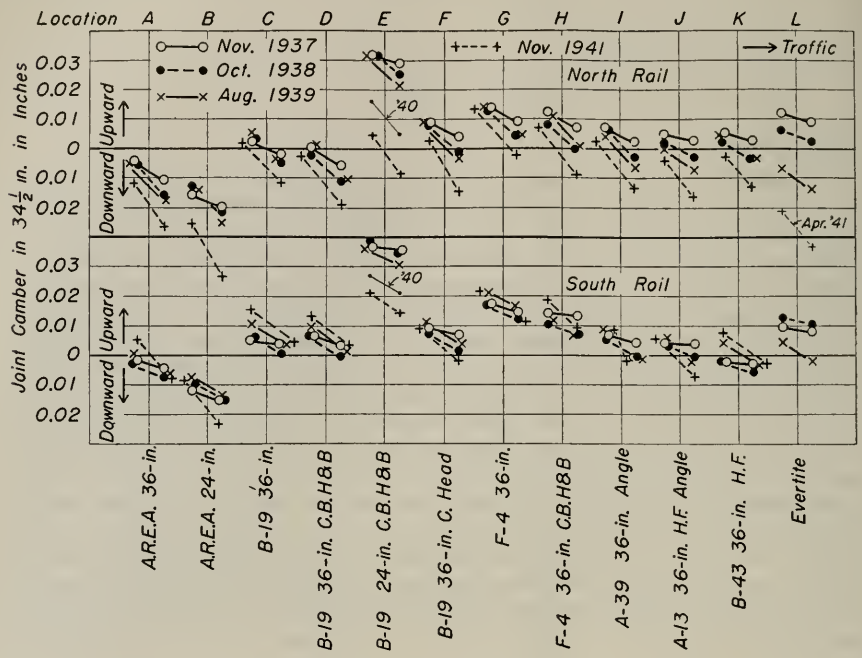


Fig. 2.—Joint Camber in 34½ in. at Leaving and Receiving Rail Ends for 60 Joints in Each Test Stretch on Pennsylvania in 1937, 1938, 1939 and 1941.

mile 98–99 show a considerable batter; other joints in this mile show a small amount. An inspection in June 1941 of the joints in this mile showed that the two middle bolts holding the wedges were working loose, although the bolts were tightened in April. On the end-hardened south rail, the decrease in joint camber on all 9 stretches has been small, doubtless due to the small amount of batter on the end-hardened rail. Even on the two stretches where a considerable change is apparent on the north rail, the south rail shows but little change from the 1937 values.

Fig. 2 gives corresponding average values for 30 joints on each of the 12 stretches on the Pennsylvania in 1937, 1938, 1939 and 1941. For the non-end-hardened north rail all of the stretches except Location E show little change in joint camber on the leaving rail through the years while the receiving rail ends for the several stretches have gone down 0.01 to 0.02 in. over the four year period. For Location E there has been considerable decrease from 1939 to 1941 on both rail ends amounting to nearly 0.03 inch. For the field end-hardened south rail only small changes have occurred except for the joints of Location E, where a decrease of almost 0.02 in. has occurred, almost all within the last two years.

Rail Surface Profiles

Rail surface profiles were taken on the running surface of the rail between points 20 in. back from each rail end. The reference points of the instrument are located on the base of the rail, so rail surface wear is included in the measurement and any changes

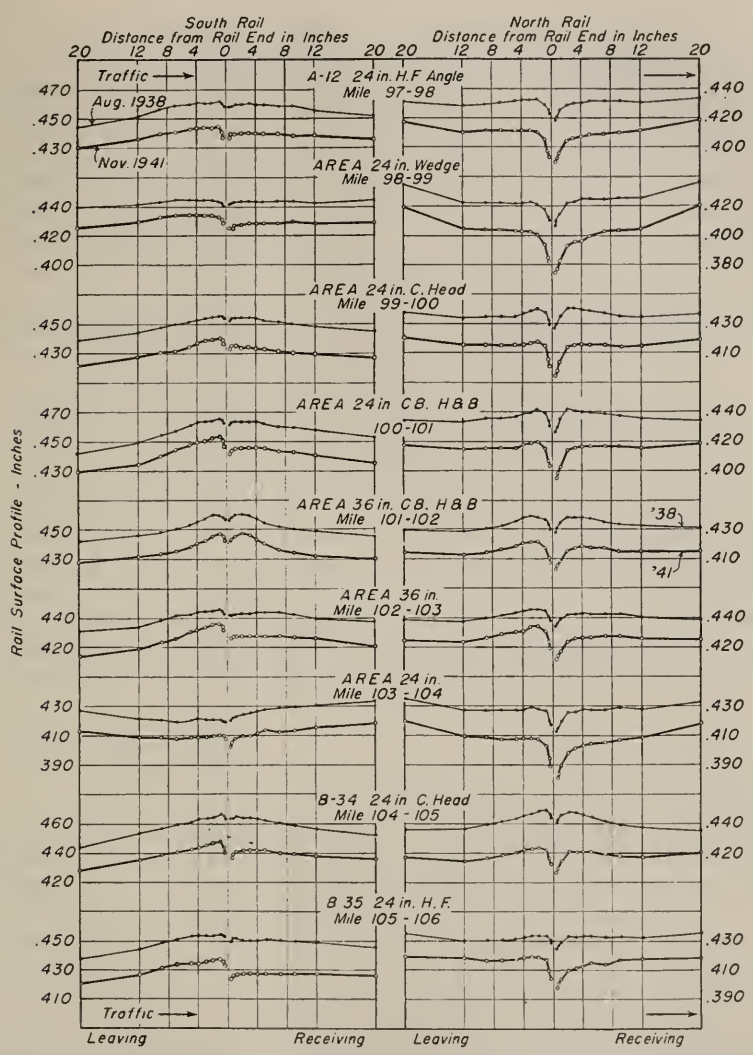


Fig. 3.—Rail Surface Profile for 1938 and 1941—Santa Fe. Average for 30 Joints on Each Stretch.

occurring at the top of the rail can be determined. The changes in the values at the point 20 in. from the rail ends may be considered a fair indication of the rail head wear between periods of measurements. Readings are taken by a dial gage on the bar at 22 intervals along the rail surface. The profile gives information on the change in the rail surface due to wear, flow, batter, camber of bar, and the bending or droop of the joint for successive years. In Figs. 3 and 4 are plotted average values of the changes in elevation of the rail surface profile measurements made in 1938 and 1941. The 1938 readings have to be used as the base because the present type of instrument was not developed in 1937 when the test stretches were installed.

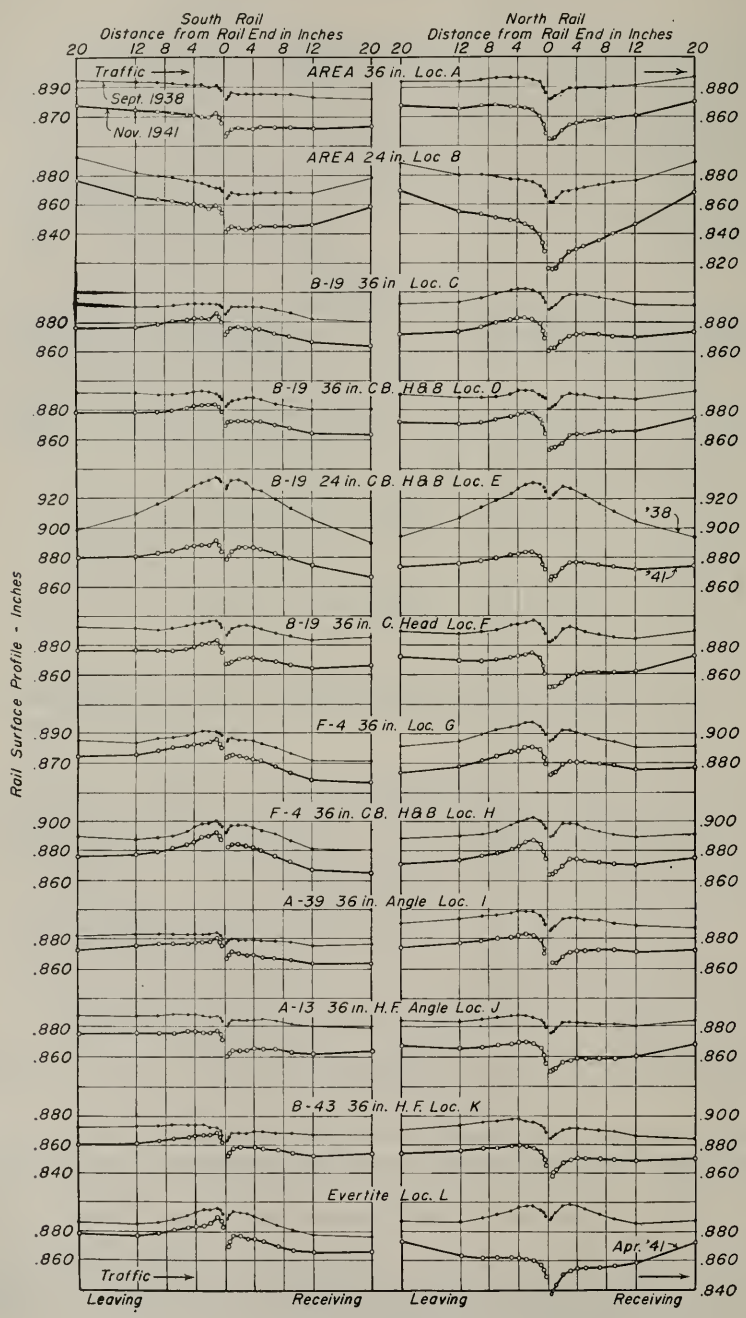


Fig. 4.—Rail Surface Profile for 1938 and 1941—Pennsylvania. Average for 30 Joints on Each Stretch.

In Fig. 3 are plotted the average rail surface profiles for 15 joints on each rail for the test sections on the Santa Fe. Considering the difference in rail height at points back 20 in. from the rail ends it is seen that the average rail wear for the 3 year period amounts to 0.016 in. The outstanding feature of the profiles is that, in general for any stretch, the profiles for 1938 and 1941 are nearly parallel throughout their length except for the batter developing at the two or three inches near the rail ends. Where joints originally had a high camber they still have almost as high a camber, or where they had a low camber initially the camber has not become appreciably lower. In other words there has been but little tendency for the joints to droop. The differences at the few inches near the rail ends represent the battering of the rail ends which is quite marked on all sections of the non-end-hardened north rail, two sections showing a considerable amount of batter. The end-hardened south rail shows only a small amount of batter. A frequent reversal of traffic in train operation over this track has doubtless minimized batter differences at the two rail ends of a joint.

The average rail surface profiles for 15 joints on each rail for each of the test stretches on the Pennsylvania are shown in Fig. 4. The average rail wear for the three year period for all the stretches at points back 20 in. from the rail ends amounts to 0.017 in. for the 42,500,000 gross tons of traffic between the two sets of readings. In most of the stretches, the profiles for 1938 and 1941 are nearly parallel throughout their length except over the two or three inches at the rail ends where the batter has developed. Variations from such parallel profiles are found in the north rail of location B, AREA 24-in. full bearing bars, both rails of location E, 24-in. controlled bearing head and base bars, and the north rail of location L, the Evertite bars that have been removed. At the locations mentioned there has been a lowering of the joints in addition to that part due to rail wear and batter. The field end-hardened south rail shows a smaller amount of batter than the north non-end-hardened rail.

Out-to-Out Measurements

The out-to-out measurement is the distance between a point on the flange of the outer bar to a corresponding point on the inner bar. The main purposes of this measurement are to show approximately the amount of "pull in" of the bars and whether any cocking has taken place during a given period. The changes in the out-to-out measurements between 1937 and 1941 are given for the Santa Fe in Table 1 and for the Pennsylvania in Table 2. The original measurements made in 1937 were taken three or four months after the rail was laid so that the bars would be well seated in the joint.

The average change of out-to-out distance found for the joints on the 112-lb. rail (Santa Fe) in the period 1937 to 1940 was given in the report on Assignment 7 of the Committee on Rail, Vol. 42, page 664, as 0.05 in. for the top and 0.03 in. for the bottom. The values for the joints on the 131-lb. rail (Pennsylvania) were 0.04 in. and 0.02 in. It is apparent from the tables that the pull in for the year 1941 has been somewhat greater than in previous years. The average values for all stretches with the 112-lb. rail are 0.07 in. for the top and 0.06 in. for the bottom. The equality of these values indicates little cocking has occurred. For the joints on the 131-lb. rail the change was 0.08 in. and 0.04 in., which would give an average increase in the cocking of each bar of 0.02 in. The bolts were tightened in April 1941 on the Santa Fe; this increase of bolt tension undoubtedly pulled the joints in and may be the reason the changes are greater than on the Pennsylvania. These averages do not include the values for the Evertite joints that were removed from track in the spring of 1941.

There seems to be little characteristic difference in the changes in out-to-out values for most of the various types of joints with a few exceptions. The headfree joints show

TABLE 1.

Change in Out to Out Measurements On Joint Bars From 1937 to 1941 in Each Test Stretch on the A.T.& S.F. Ry.

Values are the combined movements of the two bars. Negative sign means movement towards rail. Each value is the average for 30 joints on each rail. Values are in inches.

Location and Type of Bar	Rail	Top Of Bars			Bottom Of Bars		
		Leaving end	Mid length	Receiving end	Leaving end	Mid length	Receiving end
		Traffic →			Traffic →		
Mile 97-98; A12	N	0	-.03	-.03	-.04	-.04	-.05
24 in. H.F. Angle	S	-.03	-.03	-.03	-.04	-.04	-.05
Mile 98-99; AREA	N	-.02	-.04	-.04	-.01	-.03	-.04
24 in. Wedge	S	-.04	-.04	-.04	-.05	-.04	-.04
Mile 99-100; AREA	N	-.07	-.08	-.11	-.04	-.04	-.09
24 in. C.B.H.	S	-.07	-.06	-.05	-.06	-.06	-.06
Mile 100-101; AREA	N	-.09	-.09	-.08	-.05	-.04	-.06
24 in. C.B.H. & B.	S	-.10	-.08	-.07	-.07	-.07	-.05
Mile 101-102; AREA	N	-.07	-.07	-.08	-.05	-.05	-.05
36 in. C.B.H.& B.	S	-.07	-.05	-.08	-.04	-.04	-.05
Mile 102-103; AREA	N	-.07	-.08	-.09	-.07	-.08	-.07
36 in. F.B.	S	-.08	-.10	-.07	-.07	-.09	-.05
Mile 103-104; AREA	N	-.09	-.11	-.12	-.10	-.10	-.08
24 in. F.B.	S	-.10	-.11	-.11	-.10	-.08	-.09
Mile 104-105; AREA	N	-.13	-.11	-.12	-.09	-.09	-.09
24 in. C.B.H	S	-.14	-.12	-.12	-.13	-.12	-.11
Mile 105-106; B-35	N	-.04	-.02	-.03	-.08	-.08	-.09
24 in. H.F.	S	-.06	-.04	-.03	-.13	-.11	-.08

F.B.- full-bearing bars; C.B.H & B- controlled-bearing bars head and base; C.B.H- controlled-bearing bars head only; H.F. - head free bars.

less pull in, as might be expected. This is true also of the wedge joint. There does not appear to be any marked difference between the hardened and the non-hardened rail. A few types of joints show appreciably more cocking than the average as for example the B–19 36-in. controlled-bearing head and base bars in location D (Table 2) on the north rail.

Special mention should be made of the values for location E, B–19 24-in. controlled-bearing head and base bars. The average change in out-to-out is quite large and is considerably more at the top than the bottom. Data for individual joints of location E show 18 of the 60 joints measured to have a pull in of between 0.30 and 0.50 in. at the top of the bars. For these joints the top of one or both of the bars is against the upper fillet of the rail web for the full length of the bar, with only a relatively small pull in of the base of the bars. In 37 of the 60 joints there had been only a relatively small amount of pull in of the tops of the bars. The average value for the tops of the bars given in the table is composed of individual values that are mostly either small or large. It will be remembered that the joints in this location originally had very high camber but now the joints have gone down to approximately a level position. The rail ends in this location have not battered any more than for the other locations.

It has previously been stated that the average departure from verticality of one bar of two for the 112-lb. rail was 0.06 in. The departure of bars on 131-lb. rail was stated to be 0.04 in.

TABLE 2.

Changes in Out to Out Measurements on Joint Bars From 1937 to 1941 in Each Test Stretch on the P. R.R.

Values are the combined movements of the two bars. Negative sign means movement towards rail. Each value is the average for 30 joints on each rail. Values are in inches.

Location and Type of Bar	Rail	Top Of Bars			Bottom Of Bars		
		Leaving end	Mid length	Receiving end	Leaving end	Mid length	Receiving end
		Traffic →			Traffic →		
A. AREA 36 in. F.B.	N	-.06	-.07	-.06	-.03	-.04	-.02
	S	-.07	-.09	-.06	-.05	-.07	-.04
B. AREA 24 in. F.B.	N	-.07	-.09	-.08	-.08	-.04	-.07
	S	-.08	-.09	-.11	-.03	-.09	-.06
C. B-19 36 in. F.B.	N	-.07	-.01	-.10	-.03	-.06	-.05
	S	-.05	-.08	-.09	-.03	-.06	-.05
D. B-19 36 in. C.B. H & B	N	-.11	-.11	-.12	-.04	-.04	-.05
	S	-.06	-.07	-.08	-.02	-.04	-.08
E. B-19 24 in. C.B. H & B	N	-.25	-.19	-.20	-.10	-.08	-.04
	S	-.24	-.17	-.16	-.08	-.05	-.01
F. B-19 36 in. C. head	N	-.04	-.07	-.08	+.01	-.03	-.06
	S	-.04	-.08	-.08	-.01	-.05	-.04
G. F-4 36 in. F.B.	N	-.07	-.09	-.11	-.05	-.06	-.08
	S	-.07	-.06	-.06	-.05	-.05	-.04
H. F-4 36 in. C.B. H & B	N	-.09	-.06	-.10	-.04	-.06	-.07
	S	-.03	-.05	-.06	-.02	-.04	-.05
I. A-39 36 in. Angle F.B.	N	-.11	-.05	-.05	0	-.01	-.03
	S	-.03	-.06	-.09	+.01	0	-.01
J. A-13 36 in. H.F. Angle	N	0	+.01	+.02	-.02	-.01	-.02
	S	-.01	-.02	-.01	-.03	-.05	-.04
K. B-43 36 in. H.F.	N	-.03	-.04	-.01	-.04	-.07	-.02
	S	0	-.04	-.01	-.02	-.07	-.03
L. Evertite.	N	+.04	-.08	-.04	-.16	-.12	-.02
	S	+.10	-.03	+.02	-.16	-.08	-.08

* Averages for only 15 joints

+ Values given under leaving and receiving for the top of bars are the distances from the ends of the outer bar to the edges of the base of the leaving and receiving rails respectively.

Bolt Tension on the Santa Fe

In April 1941 the bolts were tightened in all the test joints on the Santa Fe. In this tightening the bolts were set to a general average tension to range between 12,000 and 15,000 lb. except for 6 joints in each stretch that were set to an average tension of 8,000 lb. Just before this bolt tightening, the existing tension as of April 1941 was measured in 24 joints for each mile stretch. The existing tension in April 1941 is given in Table 3 together with the tension as reset in the same joints in September 1939 to show the loss of tension in the bolts over the 19 months period. The average values given are for the same 24 joints in each stretch; none of these bolts was tightened during this time. For some unknown reason the general average value of the tension reset in September 1939 was somewhat lower than had usually been planned; it ranged from about 7,000 to 11,000 lb. for the several stretches. The average loss in tension ranged from 2,000 to 4,000 lb. per bolt. This amount seems to be a moderate loss over this long a period of time even though the reset tension could be called rather low to start with.

TABLE 3

Bolt Tension on A.T. & S.F. Ry.
Values are average of 24 joints in each stretch.
112 lb. R.E. Rail Values are in thousand of pounds

Location and Type of Bar	Tension as Resot September 1939							Existing Tension April 1941							
	Lv. Bolt No. Rec.							Lv. Bolt No. Rec							
	1	2	3	4	5	6	Av.	1	2	3	4	5	6	Av.	Loss
	Traffic →							Traffic →							
Mile 97-98;A-12 24 in.H.F.Angle Bar	13.6	9.0	8.7	9.8			10.3	8.1	5.6	5.3	7.0			6.5	3.8
Mile 98-99; AREA 24 in. Wedge	12.5	*	*	10.7			11.6	10.5	*	*	7.9			9.2	2.4
Mile 99-100;AREA 24 in.C.B.,Head Only	8.4	6.5	6.7	8.7			7.6	6.5	4.4	4.0	6.2			5.0	2.6
Mile 100-101;AREA, 24 in.C.B.,Head and Base	9.9	7.9	8.1	9.7			8.9	6.8	5.1	4.6	6.8			5.8	3.1
Mile 103-104; AREA 24 in. F.B.	7.9	6.8	6.6	7.3			7.2	4.4	3.0	2.3	2.7			3.1	4.1
Mile 104-105; B-34, 24 in.C.B., Head Only	7.8	7.3	6.8	7.7			7.4	4.3	3.9	3.4	4.0			3.9	3.5
Mile 105-106; B-35, 24 in. H.F.	7.2	7.3	7.6	9.1			7.8	2.6	2.8	3.7	5.9			3.8	4.0
Mile 101-102; AREA 36 in.C.B., Head and Base	5.8	8.9	9.0	8.7	8.8	6.8	8.0	5.5	7.7	6.1	4.6	6.4	5.6	6.0	2.0
Mile 102-103; AREA 36 in. F.B.	9.0	9.5	8.8	8.1	9.9	8.2	8.9	6.4	7.0	4.9	3.8	7.0	5.4	5.8	3.1

* Bolt too long for extensometer.

Removal of Joint Bars From Location L

The Evertite bars in location L on the Pennsylvania track were removed from track in April 1941. A considerable amount of batter had developed on the north, non-end-hardened rail and also the railroad officers considered the noise under high speed operation to be objectionable. In 1940–1941 the test party noticed that considerable noise resulted when trains passed over many of these joints other than at very low speeds. A close observation was made of several joints when trains were passing to find the cause of this noise. It was found that in the noisy joints the bars were bearing on the web of the rail and on the fishing surfaces of only one rail end. This left the other rail end of a joint free to move up and down as the train passed the joint. This condition was apparently caused by some difference in fishing height of the two adjacent rail ends. These bars could not correct this condition as they have a very short bearing at the top and were already pulled in against the web of the rail.

When the bars were removed from track it was found that the bearing of bar on the web of the rail was almost universal, there not being more than ten or twelve bars in the entire stretch that did not have the web in contact with the rail between the inner bolt holes. In some cases a heavy vertical ridge was noted at the mid-length, indicating that heavy bearing on the web had worn the bars except at the rail gap. There was also evidence of considerable longitudinal movement back and forth on many of the

bars. The principal bottom bearing areas were found to be at the bar ends for a length of approximately 2½ in. and for 2 in. each way from the rail ends. While there was no means of measuring the amount of resistance to negative moment developed in the joint, it was evident from observations under traffic that the negative moment developed was small, probably almost negligible. This was apparently caused by the short length of fishing surface at the top of the bar and the lack of effective bearing thereon. The joint appeared to have considerable up and down motion as trains passed. Skewed or cocked bars did not seem to affect the track line, which in general was good.

Upon removal from track, 30 joints (60 bars) were examined for transverse cracks on the bar fishing surfaces, using a small magnet and magnaflux. No serious cracks were found. Several minute cracks were found, perhaps 10 in all. These were mostly on the top fishing surface and were only ⅛ to ½ in. long and probably not more than 0.02 in. in depth; none had progressed beyond the edge of the fishing surface. In fact, there was doubt in some cases whether a crack really had started or whether metal had merely flowed. The few cracks at the bottom of the bars were of the same nature. All of the cracks found were not far from the rail ends. The bolt holes in the bars were also inspected for cracks, but none was found, even though several bars gave evidence of heavy bearing on the bolts and at the edges of the bolt holes. The first bolt on the receiving rail end was usually bearing against the back side of the bolt hole, and in some cases the bearing was severe enough to have worn the bolt to a depth of $\frac{1}{16}$ to ⅛ in. However, no bolts were bent.

This half-mile stretch of Evertite joints (section L) has now been abandoned as part of the test, and the Evertite bars have been replaced with P.R.R. F–7 36-in. controlled-bearing head and base bars.

Conclusions

The following comments are given as indicating contemporary trends and conditions in regard to certain features of the test joints and track. These trends and conditions will undoubtedly continue and develop further to permit more definite conclusions to be drawn.

In general the end-hardened south rails on both test tracks in the four year period since laying have shown improved resistance to rail end batter, only a small amount having been developed. In the same length of time, the non-end-hardened north rails of both tracks have developed an appreciable amount of batter for all the types of test joints.

The Evertite bars of location L on the Pennsylvania were removed from track in April, 1941. A considerable amount of batter had developed in the non-end-hardened north rail and due to the fact that almost all of the bars were bearing heavily against the web of the rail between the inner bolt holes proper maintenance of the joints was impossible. Many of the joints had become noisy under traffic.

Two test sections are beginning to show a greater than normal amount of batter on the non-end-hardened north rails. These sections are the AREA 24-in. wedge joints in mile 98–99, the AREA 24-in. full bearing bars in mile 103–104 on the Santa Fe. The B–19 24-in. controlled-bearing head and base bars on the Pennsylvania have lost their initial high camber and the rail surface profile is now similar to the profiles on the other sections. The rail batter of these joints is not greater than for other sections.

The average rail head wear back away from the joint for a three year period from 1938 to 1941 averages 0.016 in. for the 112-lb. rail of the Santa Fe for a tonnage of

33,500,000.* For the same period the rail head wear on the 131-lb. rail of the Pennsylvania averages 0.017 in. for a tonnage of 42,500,000.*

So far there has been little tendency for the joints to droop, the differences in rail surface profile over the four-year period since the rail was laid is due to rail surface wear and batter. Since droop has been found to be influenced by wear of the rail and bar fishing surfaces, the lack of droop may be taken as an indication of small wear on those surfaces.

Report on Assignment 8

Investigate Joint Bar Failures and Give Consideration to the Revision of Design and Specifications

Ray McBrian (chairman, subcommittee), J. B. Akers, W. T. Alexander, C. B. Bronson, W. J. Backes, W. C. Barnes, L. H. Bond, W. J. Burton, H. A. Cassil, W. A. Duff, P. O. Ferris, F. M. Graham, F. S. Hewes, W. H. Kirkbride, B. R. Kulp, G. M. Magee, R. W. Marye, C. E. Morgan, W. H. Penfield, G. A. Phillips, B. H. Prater, J. C. Ryan, R. T. Scholes, A. N. Talbot, Barton Wheelwright.

This report is offered as information with the recommendation that the subject be continued.

The previous reports on this subject included information obtained by a questionnaire relative to the number of joint bar failures, theories as to cause, suggested measures to eliminate any cracking, reports of photoelastic studies, data on fatigue tests and observational measurements of bars in track.

As a part of the cooperative work that has been carried on for several years past with the University of Illinois (Stresses in Track Investigation), a rolling-load machine was designed and built to test a full size assembled rail joint.

Rolling load tests have been conducted more or less continuously for two years with this machine and valuable information has been reported in the various committee reports. This information has dealt with fatigue life of joint bars, wear, stresses, effect of bolt tension, effect of abnormal conditions of joint bar fit, behavior of various designs of bars, etc.

While much has been done through the various tests, the committee feels that there is still much valuable information to be obtained, and arrangements were concluded for the following tests to be made on the rolling-load machine at the University of Illinois, tests to be started this year.

(A) Effect of "cocked" position of bars.
- 2 tests at 15,000 lb. bolt tension
- 2 tests at 35,000 lb. bolt tension

Tests on 24-in. bars, ⅛ in. cocking and ⅛ in. gap.

(B) Effect of design of bars.
- 2 tests of headfree 24-in. bars at 35,000 lb. bolt tension
- 2 tests of headfree 24-in. bars at 15,000 lb. bolt tension
- 2 joints with bar relief at 15,000 lb. bolt tension
- 1 joint with rail end relief at 15,000 lb. bolt tension

* The above tonnage figures represent gross tons of traffic carried and include freight and passenger trains and locomotives.

(C) Effect of bolt tension on rail end breakage.
2 tests of joints at low bolt tension

(D) Determination of fatigue strength of joint bars.
Joint tests to be made with 15,000 lb. bolt tension at 30,000, 35,000, 45,000 and 55,000 lb. wheel loads

Improving Physical Properties

As previously reported, four lots of 100 pairs of bars each were installed in the track of the Chicago, Burlington, & Quincy, near Ft. Morgan, Colo., M.P. 460 to 461.8. The four lots are all of the same rolled section, consisting of:

(a) Common chemistry, common heat treatment.
(b) Common chemistry, common heat treatment, plus flame hardened on top bearing surface at center.
(c) Common chemistry, water quenched and drawn.
(d) Rail steel chemistry, heat-treated (yield point minimum of 85,000 lb. per sq. in. and tensile strength of 120,000 lb. per sq. in.).

Observational measurements were made during the year and the traffic carried over this test and the resultant joint bar wear are not yet sufficient to justify definite conclusions.

Careful examination was made of all joint bars removed for evidence of cracks. One bar made of rail steel was found to have two small cracks on the top fishing surface.

Report on Assignment 9

Corrugated Rail—Causes and Remedy

Effect Upon Riding Qualities of Tracks and Upon the Costs of Track and Equipment Maintenance

Maro Johnson (chairman, subcommittee), S. E. Armstrong, W. C. Barnes, N. J. Boughton, C. B. Bronson, E. E. Chapman, H. R. Clarke, E. J. Cullen, J. M. Farrin, F. W. Gardiner, C. J. Geyer, J. L. Gressitt, W. H. Hillis, G. M. Magee, Ray McBrian, C. E. Morgan, J. C. Patterson, W. H. Penfield, A. N. Reece, L. H. Scheifele, F. S. Schwinn, A. N. Talbot, W. P. Wiltsee, R. P. Winton.

This is a progress report presented as information.

Preliminary consideration of this subject suggested two possible methods of getting a start; (1) a questionnaire and (2) a review of studies made by others. It was concluded that the questionnaire would prove the most effective source of information on the prevalence of corrugations, the conditions under which they occur, and their effect on track maintenance and train operation.

A complete list of questions was sent to officers of the larger roads who answered them quite generally. Most replies acknowledged more or less corrugated rail. Some, however, reported only a few continuous miles, or shorter stretches at isolated locations. Apparently corrugation occurs under all conditions of track, ballast and traffic, on tangent and curves, up-grades and down, where steam is worked and where the train is coasting, although it does not prevail under all of these conditions on any one road. Locations

where corrugation is said to be most prevalent are on curved track, at the foot of grades where the speed is high, and on tangent track where the gage is wide. Objectionable manifestations mentioned are noise and vibration, and in extreme cases rough riding track. The effects are increased mechanical wear on ties, rail and fastenings; decreased life of rail; and increased outlay for labor in smoothing the track.

The information received does not permit of any conclusion as to the cause of corrugation, and theories as to the cause were advanced by only one correspondent who expressed the opinion that vibration and oscillation of the cars were contributing factors.

Two roads, the Pennsylvania and Lehigh Valley, have used grinding machines for the removal of corrugations; but according to many replies, the conditions are not serious enough to receive any particular consideration. Due to the more or less negative character of the information received, it has not been thought necessary to present it in detail; but a statement as to the prevalence of corrugation will be prepared later.

Inquiries regarding investigations by others disclosed that the street railway people, on whose tracks in paved streets corrugation is especially prevalent, through a committee of the American Electric Railway Engineering Association, now the American Transit Association, had made a complete and exhaustive study which was reported in the Proceedings of that association from 1925 to 1930, inclusive.

The conclusions from this study are that the primary cause is overloading of the rail surface, and that the resulting flow of the surface metal, rather than abrasive wear, is the chief element in the formation of corrugations, this progressive flow being caused by synchronus wheel pounding added to the aggregate of those stresses which the rail is called on to bear.

Due to the repetitious character of the loading coming upon the rail, the committee recommended that the upper safe limit of stress for rail steel should be the endurance limit of the steel (placed approximately at 50,000 lb. per sq. in.). While most of these conclusions were based on studies of track in paved streets, there seems to be no reason why similar causes or conclusions do not apply to steam railroad track.

Various means of preventing or delaying corrugation were suggested by the committee, the principal ones being improvement in the character of the rail steel and enlargement of the contact surface between wheel and rail through changes in the contour of wheel tread and rail head.

Pending some tangible improvements from such measures, many street railway companies have been grinding the rail surface at intervals as close as two years, and a number have ground the rails before placing them in track, instances being cited of corrugations appearing in the rails of underground lines within two weeks of their being laid in track. The reasons for pre-grinding is the belief that there are enough irregularities in the rail surface as rolled to produce vibration or impact loads which will start corrugation.

Report on Assignment 10

Development and Characteristics of Fractures Under Engine Burns in Rail

Together with Investigation as to the Effectiveness of Welding up Engine Burns by Oxy-Acetylene or Electric Methods

J. B. Akers (chairman, subcommittee), W. T. Alexander, J. E. Armstrong, W. C. Barnes, L. H. Bond, N. J. Boughton, C. B. Bronson, H. A. Cassil, E. E. Chapman, H. R. Clarke, J. M. Farrin, F. W. Gardiner, G. W. Harris, B. Herman, W. H. Hillis, Maro Johnson, G. M. Magee, E. E. Oviatt, Philip Petri, B. H. Prater, R. T. Scholes, F. S. Schwinn, G. R. Smiley, W. P. Wiltsee, R. P. Winton, Louis Yager.

This is a progress report submitted as information.

Engine burns, and fractures that sometimes appear beneath them apparently have no relation to quality of rail steel. It is well known that engine burns are the result of spinning of drivers of locomotives. They are most frequently observed at places where trains may stop, as at stations, crossings, signals, water tanks and other similar places. The spinning of locomotive drivers creates excessive heat and the rail steel is reduced to a molten condition locally. These engine burned areas may be shallow, or an appreciable portion of the steel may be lost out of the top of the rail head. As a result of the damage caused by the excessive heat, a fracture is, in some cases, started immediately under the engine burn and progresses downward. Unless the rail is removed from the track, the defect will grow until rupture occurs. These engine burn fractures can seldom, if ever, be located by visual inspection; but they can generally be located by the detector car.

This defect in rail falls under the classification of Detail Fractures, and seems to be the result of damaged steel.

Statistics are being gathered to show the prevalence of rails removed because of the presence of engine burn fractures, whether service or detected failures. All members are requested to keep such a record and give it to the committee. It is desired to have this information compiled so as to segregate service from detected failures, stating the number of engine burn fractures per 100 track miles, the miles per engine burn fracture and the year or period covered by the report.

The committee has made some tests of rails with and without engine burns and some on which the engine burns have been repaired by some form of welding, but no definite conclusions have yet been reached. The committee expects to continue these tests on individual railroads, and also through the assistance of other agencies.

This is such an important subject that the committee requests that it be discussed freely, and will appreciate any and all information that can be provided by the members as to methods of repair, as well as the efficiency of those repairs.

Eighth Progress Report of the Joint Investigation of Fissures in Railroad Rails

By H. F. Moore

Research Professor of Engineering Materials, University of Illinois, in Charge of the Investigation

I Field Tests For Batter of End-Hardened Rails in Service on the Chesapeake and Ohio Railroad

By Russell Jensen and N. J. Alleman

1. Batter and Hardness Measurements.—Batter and hardness measurements on the end-hardened test rails on the Chesapeake & Ohio near Carey, Ohio, have been continued, the April 1941 measurements having been made after a total of 77 million tons of traffic had passed over this rail. The methods of making these measurements were the same as last year, using the 48-in. batter gage and the portable Brinell hardness machine. The method used to measure batter was to lay a 24-in. straight edge on the plotted profile curve touching the highest point of the curve near the end-hardened zone (usually 2 to 4 in. from the end of the rail), and to measure the distance from the rail surface to the straight edge at a point ¼ in. from the end of the rail. This distance

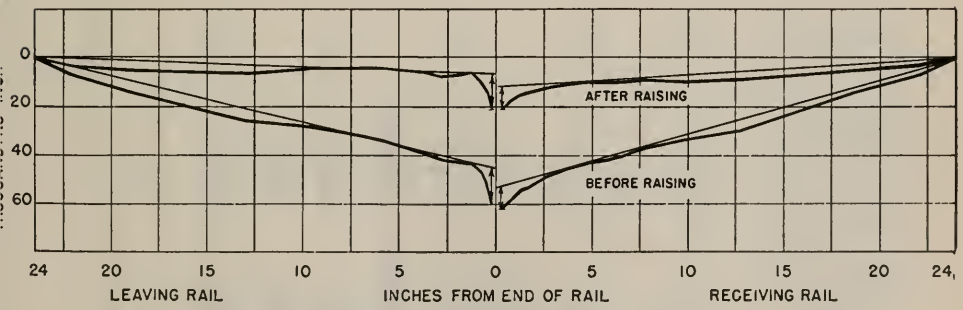


Fig. 1.—Profile of Joint Raised by Tamping Up, Showing No Effect on Batter.

is the batter. The method is illustrated in Fig. 1, where the straight lines tangent to the profile curves represent the 24-in. straight edge and the distances marked by arrows are the batter values.

Table 1 gives a complete summary of the batter values obtained in this manner for the various end-hardening processes. It will be noted that the batter values for the leaving rails increase quite consistently with the amount of traffic, whereas the values for receiving rails in some cases decrease appreciably. Quite possibly this is due to the wearing down of some of the original high spots three or four inches from the receiving end, thus tending to straighten out the receiving rail. Also, the end of the receiving rail is now from 0.002 in. to 0.010 in. lower than the end of the leaving rail, on the average,

Table 1

Average Batter in Thousandths

Traffic—Million Tons		June 1939 1.85	Oct. 1939 21.5	April 1940 38.0	Oct. 1940 59.0	April 1941 77.0
Proc. 7 Oxweld	Lv.	5.62	9.05	9.24	9.32	10.3
	Rec.	7.96	7.96	6.66	4.53	3.9
	AV.	6.79	8.5	7.95	6.92	7.1
Proc. 9 Free Held Torch	Lv.	4.60	7.49	8.56	9.08	9.3
	Rec.	7.14	7.61	7.49	7.00	8.0
	AV.	5.87	7.55	8.02	8.04	8.6
Proc. 10, Hard Not Rehardened Graham's	Lv.	3.19	5.81	5.00	4.80	4.4
	Rec.	6.69	5.94	4.37	4.00	4.7
	AV.	4.93	5.87	4.68	4.40	4.55
Proc. 10, Hard Rehardened Graham's	Lv.	3.74	4.15	5.42	5.71	5.8
	Rec.	6.03	4.04	4.65	4.71	4.9
	AV.	4.88	4.09	5.03	5.22	5.3
Unhardened	Lv.	7.67	11.5	12.3	12.1	12.4
	Rec.	11.9	13.5	13.7	10.8	11.5
	AV.	9.79	12.5	13.0	11.45	12.0
Proc. 10, Soft Graham's	Lv.	4.18	6.54	8.04	7.50	8.1
	Rec.	6.78	6.95	7.69	7.80	8.2
	AV.	5.48	6.74	7.86	7.65	8.15
Proc. 2, Mill E Gas heat, air quench	Lv.	5.06	7.08	7.59	7.11	7.3
	Rec.	8.43	8.16	7.39	6.86	7.2
	AV.	6.74	7.62	7.49	6.98	7.25
Proc. 3, Mill I Water quench, Rolling heat	Lv.	5.45	7.15	7.75	7.13	7.7
	Rec.	4.04	4.98	5.35	5.49	7.0
	AV.	4.74	6.06	6.55	6.31	7.4
Proc. 1, Mill B Induction heat, Water quench	Lv.	3.87	6.10	7.21	7.64	10.1
	Rec.	2.68	3.67	3.85	3.54	4.6
	AV.	3.27	4.88	5.53	5.59	7.4
Proc. 6, Mill D Brunorized, Air quench	Lv.	1.78	3.32	4.15	3.96	5.6
	Rec.	1.39	1.91	2.21	2.48	4.9
	AV.	1.58	2.61	3.18	3.22	5.3

Batter measured at point ¼-in. from end of rail.

which may cause the wheels to "skip" a small distance on the receiving end, thus decreasing these batter values.

Fig. 2 shows a comparison of the batter for June 1939 when the measurements were first taken with the 48-in. gage, and April 1941 after passage of 77 million tons of traffic. These batter values are the average of measurements on approximately 100 joints for each process.

The average joint profiles for June 1939 and April 1941 are shown in Figs. 3 and 4. Although the batter is relatively small, practically all of these joints now show a decided

(text continued on page 613)

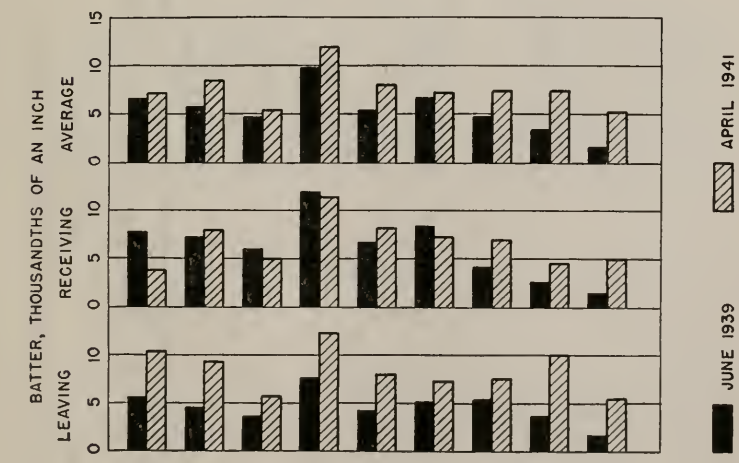


Fig. 2.—Comparative Batter, End-Hardened Rails.

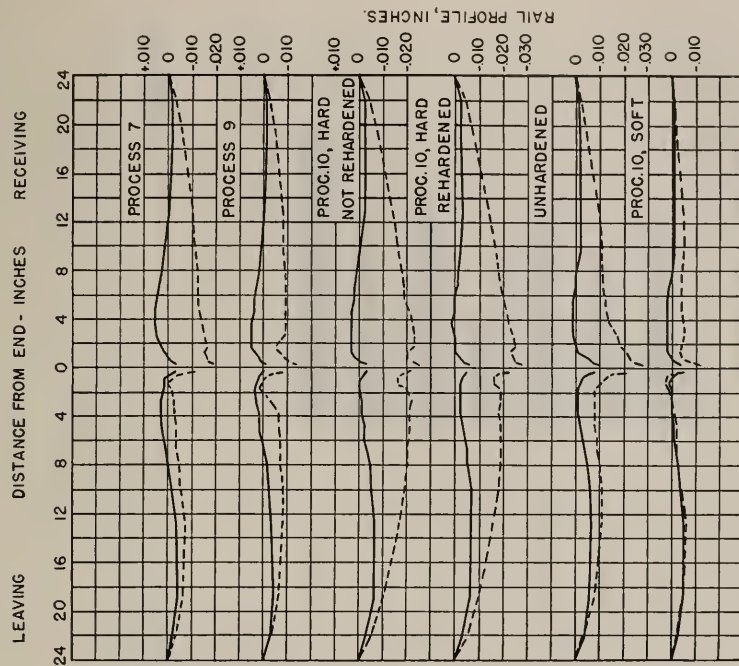
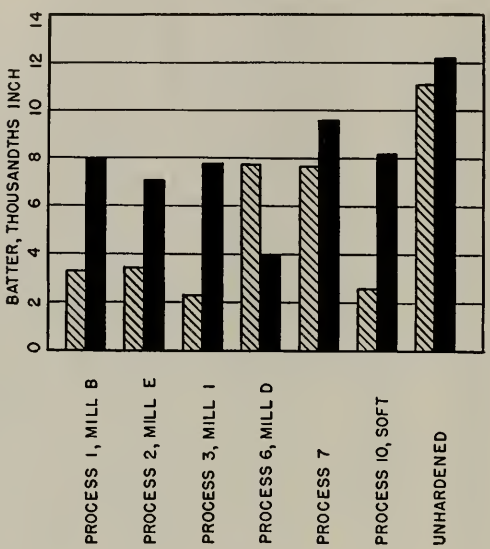


Fig. 3.—Average Joint Profiles, Field End-Hardened Rails.



ROLLING MACHINE

TRACK

Fig. 5.—Comparison of Batter in Track and Rolling Machine After an Estimated Passage of 30,000,000 Tons.
Track batter based on batter of "leaving" rails.

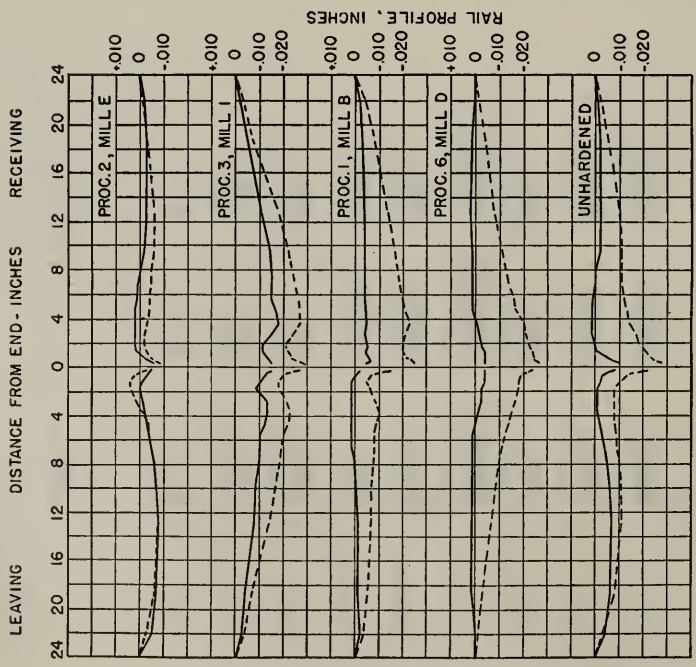


Fig. 4.—Average Joint Profiles, Mill End-Hardened Rails.

TABLE 2

BRINELL HARDNESS NUMBERS AND RANGE OF HARDNESS FOR ALL END-HARDENING PROCESSES

	April 1939, when rails were laid			*April 1941 after 77 million tons*			
	Number of Readings	*Range, Brinell Hardness Number*	*Average Brinell Hardness Number*	*Number of Readings*	*Range, Brinell Hardness Number*	*Average Brinell Hardness Number*	*Average Increase in Hardness Numbers*
Field Hardening Methods							
Process 7	70	296–342	315	78	356–387	369	54
Process 9	33	359–488	423	75	368–516	426	3
Process 10, Soft	71	298–425	349	92	321–405	364	15
Process 10, Hard	44	408–532	485	15	470–564	520	35
Process 10, Rehardened	--------	--------	--------	87	334–425	366	--------
Mill Hardening Methods							
Process 2, Mill E	48	282–340	314	118	323–390	361	47
Process 3, Mill I	49	351–402	373	83	349–425	384	11
Process 1, Mill B	38	321–450	409	102	323–460	408	—1
Process 6, Mill D	44	305–359	333	86	344–399	374	41
Unhardened	76	234–261	246	79	269–306	287	41
Total Readings	473	--------	--------	815	--------	--------	--------

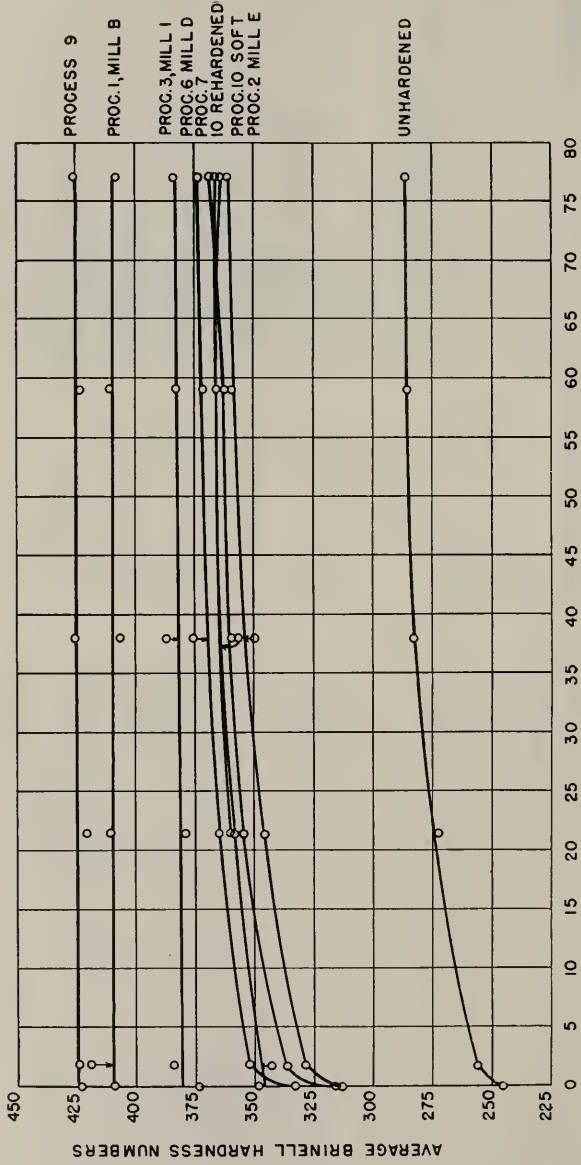


Fig. 6.—Effect of Traffic on Hardness of Rail Tread.

(text continued from page 608)
droop. Several of these low joints were raised to a level condition by tamping up by the section crew, and measurements taken before and after tamping showed that the measurement of batter was not appreciably affected inasmuch as the contour of the rail surface near the center of the joint remained unchanged. Fig. 1 shows such a joint which was tamped up about 2 in., straightening the rail until the ends were raised approximately 0.040 in. but in which the batter values were not affected.

Measurements were taken on about 100 joints shortly after all the bolts had been retightened to determine what effect the tightening had on the joint profiles and on the batter values. No appreciable change in either the profiles or the batter was observed. Of the total number of bolts, about 44 percent needed no tightening, 50 percent were given ¼ to ½ turn, and the remainder ¾ to 1 turn, none going over 1 turn.

In Fig. 5 is shown a comparison of batter on rails in track and in the rolling-load machine after 30 million tons had passed over each group. For this comparison only the leaving rails from track were used because of the inconsistency of the batter values of the receiving rails, due to different widths of gap, differences in elevation of rail ends, etc., in the track. In most cases the batter measured from rail joints in the rolling machine is much less than for those in track. Undoubtedly this difference is partly due to removal of much of the decarburized metal (0.060 in. in some cases) on the top of the rail specimens for the rolling machine in order to obtain a rolling path 1½ in. wide. Also, the gaps in the joints for the rolling machine were all spaced at ⅛ in., while those in track vary from a closed joint to ½ in. The wheel loads in the machine were set at 40,000 lb. and consequently those specimens received fewer passages of the wheel for the given total tonnage than did the track joints where the average wheel loads were estimated at 17,500 lb.

Fig. 6 and Table 2 show the effect of traffic on the hardness of the rail tread as determined by the portable Brinell machine. A total of 815 Brinell readings was taken on the rails in April after 77 million tons of traffic. In view of the fact that these curves have straightened out to the point where no appreciable increase in hardness is observed, it is thought that further complete surveys of hardness will be unnecessary.

Batter measurements were made in October 1941 on all joints after over 100 million tons of traffic had passed over this rail, but work on these data has not been completed. However, they are expected to be ready for inclusion in the oral report at the March 1942 AREA Convention.

II Laboratory Tests of Cracked End-Hardened Rails From Test Track at Carey, Ohio

By R. E. Cramer

2. **Weeping Cracks Developed in Service.**—In the October 1940 inspection of the 800 end-hardened test rails in the tracks of the Chesapeake & Ohio at Carey, Ohio, it was found that a number of rails were developing fatigue cracks on the ends of the rails about $\frac{1}{10}$ to ⅛ in. below the tread. Fig. 7 (a) is a photograph of one of the cracks indicated by the arrow and Fig. 7 (b) shows the same crack opened up. The growth rings indicate that it is a fatigue crack starting at the ground surface on the end of the rail. This type of crack has been called "weeping crack" by some railroad men, which seems to be a good descriptive name. Water carries rust out of these cracks leaving rust marks along both their edges and the water spurts on the opposite rail end of the joint as car wheels pass over the rail.

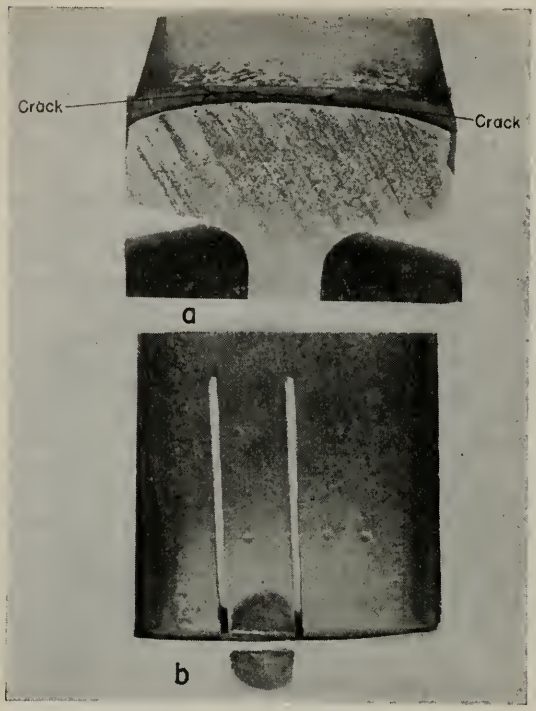


Fig. 7.—Weeping Crack on Ground Surface.

(a) Weeping crack on ground surface of an end-hardened rail as received.
(b) Same rail shown in (a) with weeping crack opened up.
Note that growth rings start at ground end of the rail.

The test track was again examined the week of October 13, 1941. The number of cracked rails found in each group of test rails is shown in Table 3, together with the average Brinell hardness readings taken by Mr. N. J. Alleman in April 1941. It will be noted that most of the cracks are in the rails of over 400 Brinell hardness except the Graham group which were rehardened below 400 and also have a number of cracks.

Six rails were selected for laboratory study and removed from track by the Chesapeake & Ohio. Six-inch pieces from each end of these rails were sent to the Talbot laboratory for study. The ground or beveled area of each specimen containing a crack was photographed at about actual size as received. A few of the cracks were photographed at 8 × magnification to show grinding scratches before polishing. Fig. 8 is an example of the appearance of a weeping crack at 5½ × magnification, as received from track, showing that the crack followed the grinding scratches. This crack was opened up and the growth rings showed that it started at the middle of its length along the ground end of the rail. The ground areas of most specimens were then polished with fine emery paper and a number of pictures taken at 10 × magnification. The polished surface was then etched 3 hours in cold 50 percent hydrochloric acid to bring out any heat checks formed during grinding. Only two rails, which were both over 500 Brinell hardness, showed heat checking and it did not appear that the weeping cracks had developed from the heat checks in either rail.

Several of the weeping cracks were opened up, and in all cases they had started at the ground surface of the rail end and had grown inward by fatigue action as indicated by growth rings, as shown in Fig. 7 (b). Many of the cracks observed in the rails in

TABLE 3

CRACKS IN ENDS OF END-HARDENED RAILS

C. & O. Test Track, Carey, Ohio—October 1941

Joint Numbers	*Method of End Hardening*	*Leaving Rail Ends*	*Receiving Rail Ends*	*Total*	*Average Brinell Hardness*
1– 99	Oxweld Acetylene heated—No quench	1	0	1	369
100–200	Free Held Torch Acetylene heated—Water quench	3	8	11	426
201–300	Graham Hard—16 rails Same re-hardened—84 rails Acetylene heated—Water quench	3 16	6 10	9 26	520 366
301–400	Unhardened Rails	0	0	0	287
401–500	Graham Soft Acetylene heated—Water quench	8	7	15	364
540–639	Mill E Gas heated—air quench	0	0	0	361
640–739	Mill I Water quenched from rolling heat	1	6	7	384
744–840	Mill B Induction heated—Water quench	50	31	81	408
846–948	Mill D—Brunorized Air quenched from normalizing temperature	0	1	1	374
	Total	82	69	151	

track are in grinding grooves. These grooves were formed during the grinding of the rails in track with a ⅛-in. wheel used to slot between tight rail ends to make room for the beveling wheel. Altogether 40 pictures are on file at the laboratory showing the conditions of these rails.

Practically all the weeping cracks in the rails received at the laboratory started along deep grinding scratches or in notches ground with the narrow grinding wheel. The rust pitting was always quite severe along such scratches or grooves. The cracks are usually $\frac{1}{16}$ to ⅛ in. below the rail tread. Metallographic studies of the grain structures along some cracks and studies of the Rockwell hardness of the rails were made but no conditions were found that differed from those of previous tests of many end-hardened rails during the last several years. Close observation of the rails in track for one year indicates that most of the cracks are slowly progressing both across the rails and lengthwise in the rails, while a few are not showing much increase in size. Only a few rail ends have required building up by welding to date but several are

Fig. 8.—Weeping Crack as Received from Service. Magnification 5½ Times.
This picture shows the rust and pitting on the ground rail ends. It also shows the grinding marks. This crack was opened up, and the growth rings showed that it started at the middle of the length of the crack.

cracked back two or more inches along the sides of the rail heads. This produces a thin layer of steel on the tread which is cracked loose. These layers are elongating past the ends of the rails and spreading sidewise over the width of the rail head. This condition makes the batter readings on these particular rail ends inconsistent with other rails of the same group which have not developed large weeping cracks.

From the above observations we may construct the following mental picture of the development of weeping cracks. The quenching of the steel in the end-hardened rails over 400 Brinell makes them somewhat like a brittle material. Fatigue tests of notched heat-treated steels show that such steels are markedly sensitive to notches. The grinding scratches and grooves in these rails act as stress raising notches on the ground surface of the hardened steel and these are often present at the depth below the surface where the shearing stress due to the wheels probably is high. Corrosion of the freshly ground steel further weakens the surface along the notches and scratches. Corrosion-fatigue cracks may start at the stress raising scratches and spread into the hardened zones of the rails. Corrosion-fatigue requires much less load to start and propagate a crack than would be required if corrosion were not present.

One recommendation can be made, regarding these particular test rails, which seems to offer a cheap, promising method of lessening the probability of such cracks forming. That is, to cover the ground surface of the rail ends with an asphaltic paint or heavy grease to prevent corrosion immediately after grinding. This protection could be renewed each year when the angle bars are oiled which is now the practice on

this railroad. It should be emphasized that this recommendation applies only to the rails under study and might not apply to rails in other railroads.

3. **Summarizing of the Tests of End-Hardened Rails in the Test Track at Carey, Ohio.—**

1. From a consideration of batter only all of the end-hardening processes seem quite satisfactory.

2. A comparatively large number of the rails have developed weeping cracks which will eventually require building up by welding. At present it is thought that the method of slotting the rail ends in track had some influence on the development of these weeping cracks. Since all the rails in this test track were slotted, a study of rails in other tracks will be necessary before the damage due to grinding can be distinguished from that due to excessive hardness of steel.

3. Since there are fewer cracks in rails below 400 Brinell hardness than above this value, it would seem advisable to limit the hardness of end-hardened rails to some smaller hardness number.

4. When cross-slotting joints with a ⅛-in. wheel it seems highly desirable to avoid leaving notches on the ground ends of the rails, near the rail tread.

III Metallurgical Tests

By R. E. Cramer

4. **Proposed Recommended Practice for the Control Cooling of Rails.—** At the 1941 March meeting of the Contact committee of the Rails Investigation the following Revised Recommended Practice for Control Cooling of Rails was drawn up for consideration by the mills and railroads during the coming year.

PROPOSED RECOMMENDED PRACTICE FOR THE CONTROL COOLING OF RAILROAD RAILS

1. All rails shall be cooled in the regular way on hot beds or runways until the temperature is between 725 deg. F. and 1,000 deg. F., then charged immediately into the containers.

2. The temperature of the rails before charging shall be determined with a reliable pyrometer at the top of the rail head at least 12 in. from the end.

3. The handling of rails between the hot bed and the container and their subsequent removal shall be carefully conducted to avoid bending and to minimize cold straightening.

4. The cover shall be placed on the container immediately after completion of the charge and shall remain in place for at least 10 hours. After the removal or raising of the lid of the container no rails shall be removed until the temperature of the top layer of rails has fallen to 300 deg. F., or lower.

5. The temperature between an outside rail and the adjacent rail in the bottom tier of the container, at a point not less than 12 in., or more than 36 in., from the rail end, shall be recorded with reliable equipment. This temperature shall be the control for judging rate of cooling.

6. The container shall be so protected or insulated that the control temperature shall not drop below 300 deg. F. in 7 hours from the time that the bottom tier is placed in the container.

7. All control-cooled rails shall be hot-stamped "CC", except that control-cooled rails which are also end hardened shall be hot-stamped "CH".

Tests carried out during the past two winters on rails in mill cooling containers indicated the desirability of paying more attention to the cooling of the rails in the bottom tiers of the containers. The revised recommended practice places the control thermocouple between an outside rail and the adjacent rail, or against either rail, in the bottom tier of the container and specifies that the temperature in this location shall not drop below 300 deg. F. in 7 hours from the time the bottom tier is placed in the container.

It is recognized that this is a drastic change from the recommended practice adopted in 1937 which placed the control couple in the middle of the pile of rails in the container and specified that the temperature in this location should not drop below 300 deg. F. in 15 hours time. The representatives of the rail mills could not be expected to agree to meet this requirement until they have had time to experiment with methods of insulating their containers and of elimination of free air space at the ends of the containers and underneath the bottom tier of rails. These experiments may require nearly all of the winter of 1941–42, because the fastest cooling conditions will be encountered only during cold weather.

This situation was reported to the members of the AREA Rail Committee at their March 1941 meeting and it was explained that whatever changes the mills made should result in an improvement in the uniformity of rate of cooling of the rails in the containers. It was recommended that the railroads cooperate with the rail mills and accept rails meeting either the old recommended practice or the revised recommended practice during the winter of 1941–42. It is the plan of the members of the test party to make cooling tests of rails in the containers of several mills during the cold weather of the winter of 1941–42.

5. **Mill Tests of Control Cooling of Rails Using Hydrogen-Treated Ingots.**—Further experiments were made at two rail mills to gather information on the effect of control cooling on the development of shatter cracks in rails. In both cases all the tests of specimens were made in the steel mill laboratories and the members of the Rails Investigation were only observers of the tests, as this investigation no longer employs sufficient shop help to permit the slicing and etching of large numbers of test specimens at the laboratory.

6. **Tests to Determine the Temperature and Manner of Growth of Shatter Cracks in Steel Rails.**—The members of the test party of the Rails Investigation were invited to help plan and observe part of a series of tests made in 1940 and early in 1941 at the Gary rail mill by Mr. H. B. Wishart and Mr. E. P. Epler. The results of these tests were presented as a paper (Preprint No. 52) at the 1941 convention of the American Society for Metals. The following paragraphs are taken from this paper by permission of that society.

Tests 1 and 2.—Rails from Heat Numbers 85128 and 83263 were used in these tests. The ingots from both heats were treated with 20 cu. ft. of hydrogen. Only 10 specimens were used from each heat. After cutting at the hot saws the specimens were cooled in still air to temperatures of 500, 400, 300, 200, 100 and 70 deg. F. Upon reaching these temperatures, the specimens were immediately placed in a furnace at 700 deg. F. for at least 7 hours, then slow-cooled over a period of 10 hours. This temperature of 700 deg. F. and the method of cooling have been found in previous tests to completely prevent any further formation of shatter cracks in rails. Also specimens from each heat were held at 70 deg. F. for 2, 4, and 6 hours before being placed in the 700 deg. F. furnace. In each test a control specimen which was a crop end from the rails was

TABLE 4

TESTS 1 AND 2—COOLING TEMPERATURES, HOLDING TIMES AND ETCH TEST RESULTS OF RAIL SPECIMENS

Rail Specimen No.	*Temperature Deg. F. Rail Specimen Cooled in Still Air*	*Time Held Before Placing in Furnace at 700 Deg. F. Hours*	*Shatter Cracks on 6-in. Specimen*			
			Heat 85128		*Heat 83263*	
			*Long.**	*Trans.***	*Long.**	*Trans.***
500	500	0	0	0	0	0
400	400	0	0	0	0	0
300	300	0	0	0	0	0
200	200	0	0	0	0	0
100	100	0	7	1	5	0
70–0	70	0	30	8	25	6
70–2	70	2	50	9	43	7
70–4	70	4	56	8	48	5
70–6	70	6	67	14	55	12
Crop End	Cooled in Air	72 hours	78	27	69	18

* Longitudinal.
** Transverse.

cooled on the mill floor for 72 hours to represent the sensitivity of the steel to the development of shatter cracks.

To determine the presence of shatter cracks, a longitudinal slice 6 in. long and ⅞ in. below the top of the rail head was cut from each specimen. These slices were ground smooth, etched in hot 1–1 hydrochloric acid and examined for shatter cracks with low-power magnifying glasses. The number of longitudinal and transverse cracks found in each specimen is recorded in Table 4, while photographs of representative specimens are shown in Figs. 9 and 10, at approximately half natural size. The photographs are especially interesting because they show the increase in size of the shatter cracks as the specimens cooled to lower temperatures or remained at room temperature for increased periods of time before being placed in the 700 deg. F. furnace. This series of pictures furnishes very good evidence that the cracks gradually increase both in number and size with time. In the past there has been considerable discussion whether such cracks formed suddenly or grew gradually. This experiment also shows that for the particular steel used in these tests the shatter cracks began to develop in the rails while they were cooling between 200 and 100 deg. F.

Tests 3 and 4.—These experiments were designed to determine more completely the effect of holding specimens for varying lengths of time at temperatures between 400 and 100 deg. F. to ascertain if increased holding time at relatively low temperatures would allow the formation of shatter cracks. Further information was gained by using steels of different sensitivity to cracking, by varying the amount of hydrogen used in treating the ingots.

About 60 rail specimens, one foot in length, from Heats 51106 and 54007 were used. These were trucked while still at temperatures above 700 deg. F. to the mill heat treating department. In working with steel which may develop shatter cracks all experiments must be made while the specimens are cooling after rolling. Two electric furnaces and three steam heated water tanks were previously heated to the holding temperatures

(text continued on page 623)

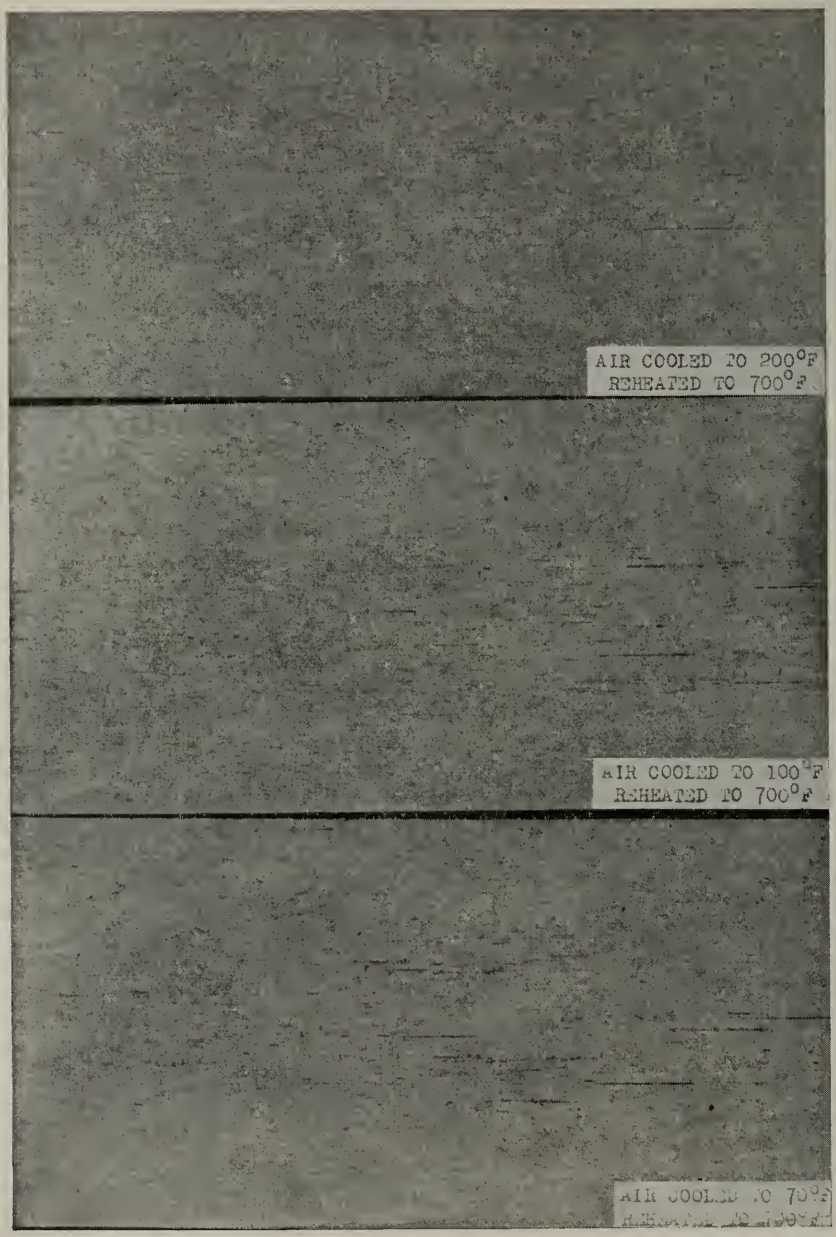


Fig. 9.—Etched Rail Specimens—No Shatter Cracks in Top Slice, Shatter Cracks in Bottom Two Slices.

Etched in hot 1–1 hydrochloric acid.

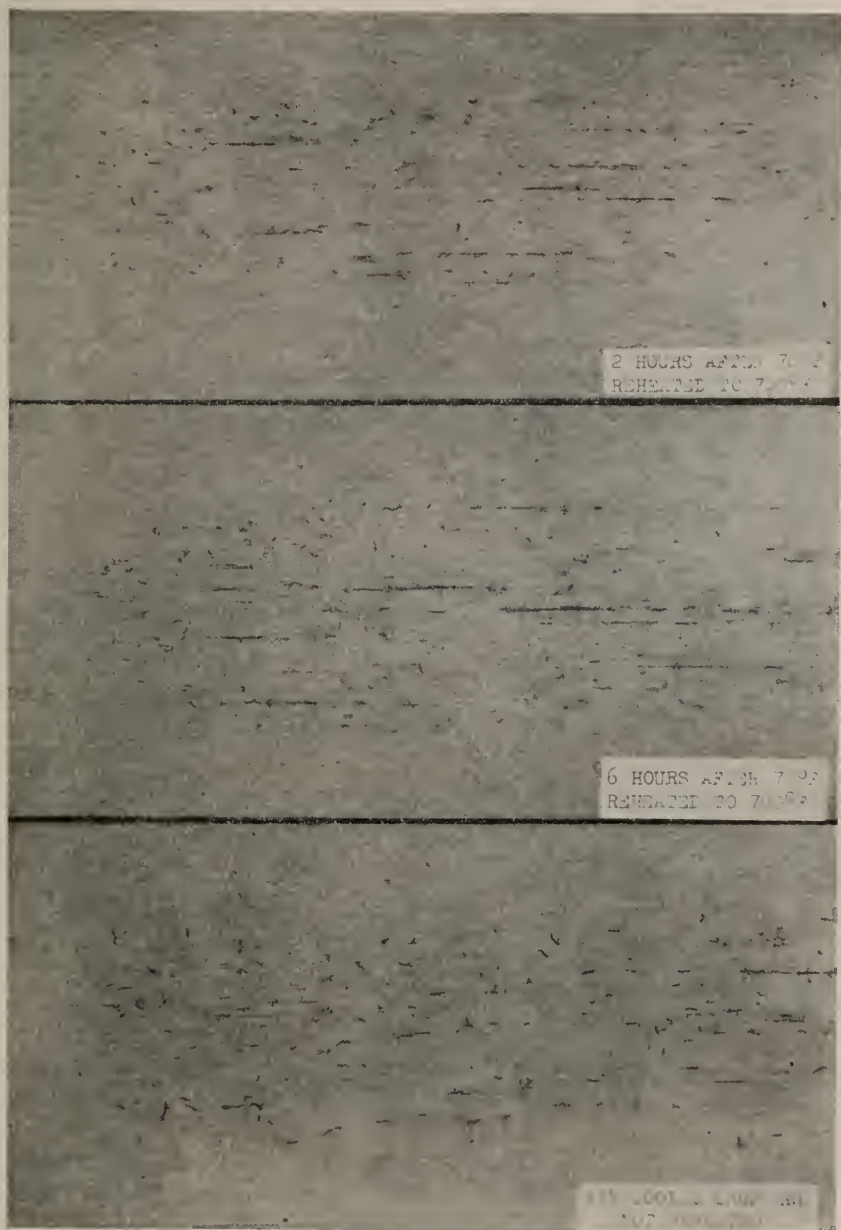


Fig. 10.—Etched Rail Specimens—Shatter Cracks in All Slices.
Etched in hot 1–1 hydrochloric acid.

TABLE 5

TEST 3—NUMBER OF SHATTER CRACKS IN SIX-INCH SLICE FROM RAIL HEADS

Heat 54007, Ingot 7—40 Cu. Ft. Hydrogen

Time in Hours Rail Specimen Held at Temp.	*Method of Cooling*	*Holding Temperatures*									
		100 deg. F.		*150 deg. F.*		*200 deg. F.*		*250 deg. F.*		*300 deg. F.*	
		*L**	*T***	*L**	*T***	*L**	*T***	*L**	*T***	*L**	*T***
0	Furnace†	113	9	18	3	8	0	0	0	0	0
2	Furnace†	80	7	96	7	58	3	28	0	4	0
4	Furnace†	92	5	74	6	45	1	24	0	9	0
6	Furnace†	97	4	68	5	74	3	25	0	13	0
8	Furnace†	120	13	72	6	70	0	22	0	22	0
10	Furnace†	103	9	83	6	65	3	25	0	20	0
0	Air‡	210	10	210	10	210	10	210	10	210	10
2	Air‡	52	3	70	6	62	0	25	0	24	0
4	Air‡	95	3	75	6	60	2	10	0	36	0
6	Air‡	73	7	90	8	80	7	9	0	26	0
8	Air‡	104	9	90	5	50	3	21	0	10	0
10	Air‡	72	7	60	8	60	6	20	1	15	0

* Longitudinal cracks.
** Transverse cracks.
† Specimens reheated to 700 deg. F. after holding at given temperature.
‡ Specimens air cooled after holding at given temperature.

(text continued from page 619)
shown in Tables 5 and 6. The rail specimens were spread out evenly over the shop floor to cool to the holding temperatures. When a group of 11 specimens reached each holding temperature, 10 of them were put in a furnace or water tank at that temperature and one was placed in a reheating furnace operating at 700 deg. F. At two-hour intervals, up to 10 hours, two specimens were removed from each furnace or tank and one specimen cooled in air while the other was placed in the 700 deg. F. reheating furnace. This furnace was operated at temperatures for 7 hours after the last specimen was placed in it and then slow-cooled over a period of 10 hours.

Tables 5 and 6 give the holding temperatures and time of holding for each specimen together with the number of longitudinal and transverse shatter cracks found in a 6-in. slice from each specimen. It will be noted that the control specimen for each test is the specimen held zero hours and cooled in air. The ingot of Heat No. 54007 was treated with 40 cu. ft. of hydrogen which produced 210 longitudinal and 10 transverse shatter cracks in the control specimen, while only 25 cu. ft. of hydrogen was used in the ingot of Heat No. 51106, producing 82 longitudinal and 14 transverse shatter cracks in the control specimen. This difference in the crack sensitivity of the two heats of steel explains why all the furnace cooled specimens of Heat No. 54007 held 2 hours or longer at 300 deg. F. developed shatter cracks while no shatter cracks developed in the specimens from Heat No. 51106, held at this same temperature up to 10 hours and furnace cooled.

It will be further observed from Table 5 that the specimen treated with 40 cu. ft. of hydrogen developed a few shatter cracks when cooled to 200 deg. F. and immediately reheated, and another specimen held at 300 deg. F. for only 2 hours developed a few cracks. The tests also show in Table 6 that holding rails treated with 25 cu. ft. of hydrogen at either 400 deg. F. or 300 deg. F. for 6 hours, followed by cooling in air was sufficient treatment to prevent the formation of shatter cracks.

Conclusions.—The following general conclusions can be drawn from these experiments:

1. Shatter cracks develop gradually both in size and number in shatter-sensitive carbon steel rails as they are allowed to cool between the range of 400 and 70 deg. F. The temperature at which shatter cracks were initially observed depended upon the sensitivity of the steel and the manner in which the rails were cooled through this temperature range.
2. Shatter crack development continues after the rails reach room temperature and are held at this temperature for increasing periods of time.
3. Conclusions 1 and 2 apply only to shatter-sensitive air-cooled rails which are not control-cooled or held between temperatures of 1,200 deg. F. to 400 deg. F. for lengths of time sufficient to properly eliminate shatter sensitivity.
4. The temperature at which shatter cracks begin to form and the amount of retarded cooling required to prevent their formation depend on the sensitivity of the steel to the development of shatter cracks.

All these tests give further confidence in the revised recommended practice for control cooling of rails and indicate that the requirements seem adequate to prevent the formation of shatter cracks in all regular production rails.

7. **Failed Rails Sent to the Laboratory for Examination.**—Special reports have been written on a considerable number of failed rails, and sent to Mr. W. C. Barnes for the rail failure statistics and to the railroads supplying the rails.

A

TABLE 6

TEST 4—NUMBER OF SHATTER CRACKS IN SIX-INCH SLICE FROM RAIL HEADS

Heat 51105, Ingot 4—25 Cu. Ft. Hydrogen

Time in Hours Rail Specimen Held at Temp.	*Method of Cooling*	*Holding Temperature*									
		100 deg. F.		*150 deg. F.*		*200 deg. F.*		*300 deg. F.*		*400 deg. F.*	
		*L**	*T***	*L**	*T***	*L**	*T***	*L**	*T***	*L**	*T***
0	Furnace†	8	1	1	0	0	0	0	0	0	0
2	Furnace†	45	4	2	0	3	0	0	0	0	0
4	Furnace†	43	2	40	0	8	0	0	0	0	0
6	Furnace†	50	2	15	0	14	0	0	0	0	0
8	Furnace†	27	1	12	0	20	0	0	0	0	0
10	Furnace†	25	0	23	0	27	0	0	0	0	0
0	Air‡	82	14	82	14	82	14	82	14	82	14
2	Air‡	30	0	28	2	40	4	40	6	29	1
4	Air‡	15	0	28	3	30	3	24	0	4	0
6	Air‡	55	7	19	0	20	2	0	0	0	0
8	Air‡	25	2	15	1	25	1	0	0	0	0
10	Air‡	20	0	10	0	15	0	0	0	0	0

* Longitudinal cracks.
** Transverse cracks.
† Specimens reheated to 700 deg. F. after holding at given temperature.
‡ Specimens air cooled after holding at given temperature.

Several rails examined had failed by gage corner shelling, being the high rails of sharp curves. It was found that fatigue cracks causing the shelling had started inside the rail heads and spread to the gage sides on many different levels. This loosened pieces of the head on the gage side which subsequently dropped out causing a rough surface on the tread. Hardness tests indicated that severe cold working by car wheels had exhausted the ductility of the rail steel, causing internal fatigue cracks. These cracks started about ⅛ in. below the surface and from ½ to 1 in. from the gage side of the head and progressed mostly toward the gage side. The contact of wheels and rail on sharp curves apparently produces conditions of stress much more severe than on tangent track, and these severe conditions produce internal fatigue cracks. This type of rail failure would require considerable study to find the best solution. This may involve consideration of the radius of the gage corners of rails, the radius between flange and tread of wheels, the canting and superelevation of the rails on the curves, or the composition of the rail steel.

Other failed rails examined included the transverse and compound fissures developed from blow holes in control-cooled rails and one transverse fissure which started at a spot where the rail had been built up by welding, as described in the following section.

IV Control-Cooled and Brunorized Rails in Service

By R. E. Cramer

8. **Service Record of Control-Cooled Rails.**—Six years have elapsed since the first control-cooled rails for use on railroads in the United States were made and sold under contract. Mr. W. C. Barnes, engineer of tests for the AREA Rail Committee reports that up to June 30, 1941, 3,863,372 tons of control-cooled rails had been purchased by railroads in the United States.

At the time this report is being written, November 15, 1941, only seven transverse fissures and four compound fissures have been reported and verified in this tonnage of control-cooled rails. Only two of the transverse-fissured rails showed any shatter cracks on etch testing, and none of the compound-fissured rails showed shatter cracks.

Both of the control-cooled rails which developed transverse fissures and showed shatter cracks on etching were from the same mill and were rolled during December 1936 and March 1937, respectively. This was during the first year when that mill made control-cooled rails under contract. At that time the control-cooled practice at that mill was not the best, but was greatly improved during the second year of production by the use of tight fitting lids on the cooling containers in place of a cover merely resting on the container; and it is significant that these rails were placed, one in the top layer in the container and the other in the next to the top layer. Since 1936 all the rail mills in the United States have improved the insulation of their control-cooling containers.

Of the other five transverse fissures which have developed in control-cooled rails, two developed from blow holes, two from slag inclusions near the tread of the rail, and the remaining fissure developed from a welded area where a worn spot, probably a wheel burn, had been built up by welding. The compound fissures both started from blow holes near the tread of the rail.

It seems probable that other control-cooled rails produced during the first year of manufacture under contract may develop transverse or compound fissures in service, nevertheless the six-year record of control-cooled rails seems distinctly good. It is believed that the improvements being made by the mills to prepare their cooling container to meet the new "Recommended Practice for Control Cooling of Rails" now being considered

for adoption will offer an even greater degree of security against the presence of shatter cracks in control-cooled rails.

Summing up the performance of control-cooled rails it is evident that control cooling has very greatly reduced fissures which can be charged against shatter cracks. Probably a few control-cooled rails will develop fissures, compound and transverse from blow holes, large slag inclusions, etc., near the tread of the rail and, perhaps, from built-up welded spots on the surface of the head of the rail. At least one faulty method of control cooling has been corrected, and insulation practice has been improved by all rail mills.

9. **Service Record of Brunorized Rails.**—In September 1941 Mr. Barnes' records showed that there were 140,251 tons of Brunorized (normalized) rail in service. During the past 11 months only 2 further fissures have been reported in the Old Process Brunorized rails. The improved Brunorizing process was put into use in April 1938, and no fissures have been reported in rails made under the improved Brunorizing process, which includes holding rails for several hours at a temperature above that at which shatter cracks will develop, after they have been rolled, and before entering the Brunorizing furnace.

V Comparison of Drop and Bend Tests

By N. J. Alleman

10. **Comparison of "A" Rails in Head-Up Tests.**—In Table 7 (a) are given results of head-up tests on 112- and 131-lb. rails received from two mills. Each rail is from a different heat and the bend test specimen is cut from the "A" rail adjacent to the standard mill drop test specimen. An examination of the data shows that no clear cut relationship between the two types of tests stands out. An unusually high number of blows is an index as to the drop test elongation but the bend test results on the same rails do not show unusually high values.

This lack of correlation of properties may be due to several factors. (1) For blows following the first, the rail may not be recentered carefully. This factor combined with the "play" between the tup on its guides may allow the tup to strike the rail as much as two or three inches away from its previous point of contact. Also hammer rebound sometimes allows the rail to receive a glancing blow. (2) In the bend test it is noted that the rails usually break within 2 in. of mid-span with the maximum elongation across the break. Under the drop test a piece 6 to 12 in. long often breaks from the rail base and the elongation across the fracture is not the maximum elongation. The rail is often twisted and buckled after the second or third blow and the energy of the succeeding blows is expended not only in exhausting the ductility across the base but also in further twisting and buckling.

Rail 768 requiring 7 blows for fracture in the drop test and developing a total elongation of 97, indicating good ductility and homogeneity, did not show energy and elongation values in the bend test appreciably higher than did Rail 766 which required only 2 blows for failure and gave a total elongation of 36.

Table 7 (b) giving data on head-up drop tests and head-down bend tests also indicates that head-up drop tests do not give a good index as to rail quality. Rail 793 required five blows for failure although the mill data sheet was marked "Pipe". A piped condition was not present in the bend test specimen, so good values were obtained.

Rails 797 and 798 are of particular interest. Drop test values indicate a normal rail. In the bend test energy values dropped to 16,000 ft. lb. and 13,000 ft. lb., respectively,

(text continued on page 632)

TABLE 7(A)

COMPARISON OF DROP AND BEND TESTS ON "A" RAILS

Supports on 4-ft. centers. Central loading. Drop tests at mill

Lab. Rail No.	Drop Test Data: Blows for Failure	Drop Test Data: Permanent Set, in. Blow 1	Drop Test Data: Elongation percent	Bend Test Data: Maximum Load, lb.	Bend Test Data: Deflection, in.	Bend Test Data: Energy for Failure ft.-lb.	Bend Test Data: Elongation percent
			112-28 Section Head-up				
770	4	0.85	5-6-7-7x-7-6 =38	298,700	4.07	83,650	6-9-10-15x-8-6 =54
772	5	0.90	5x-7-8-9-8-8x =45	287,600	5.60	116,200	7-10-14x-13-11-7 =62
774	5NB	0.90	4-7-7-7-9-8x =42	280,600	5.02U	101,200	6-10-12-12-10-7 =57
776	5NB	0.90	3-6-8-8x-11-9 =45	283,000	3.88	75,600	5-7-7x-8-7-5 =39
778	6	0.90	9-10-11-11-10-8x =59	294,600	5.53	118,200	10-14-15-15x-12-8 =74
780	5	0.90	6x-7-8-8-7-6x =42	297,400	3.93	82,000	6-7-8-8x-8-7 =44
782	2	0.90	4-5x-5-5-5-4 =28	285,600	4.71U	95,800	7-12-13-13-13-7 =65
784	4	0.85	6-7-7-8-7-5x =37	297,800	3.36	67,300	4-7-7x-7-7-7 =39
785	5	0.90	7-8-9-8-8-7x =47	285,600	3.90	76,600	7-8-9-8x-7-6 =45
788	5NB	0.90	8-9-10-10-10x-9 =56	283,300	3.72U	72,800	7-9-11-13-11-9 =60
			131-28 Section Head-up				
760	6	0.80	10x-12-13-12-10-8 =65	376,600	4.57	120,300	9-10-13x-14-13-9 =68
762	6	0.85	9-10-10-9-9-7x =54	351,900	4.49	108,800	7-7-12x-12-11-7 =56
763	6	0.75	8-10-12-13x-12-10 =65				
766	2	0.85	5-6-7x-7-6-5 =36	336,400	3.69U	84,600	9-10-12-12-10-8 =61
768	7	0.80	13-16-18x-17-13-10 =97	360,600	4.02U	98,300	10-12-14-14-12-11 =73
789	5 NB	0.75	6-8-10-10x-10-9 =53	413,200R	4.41	125,500	9-12-14x-12-10-8 =65
790	6	0.70	9-11-11x-11-9-7 =58				
792	5	0.75	6-7-7x-7-6-5 =38	368,800	3.40U	86,500	7-9-12-12-12-10 =62
794	5	0.65	5x-5-6-7-6-5x =34				
796	3	0.75	3-4-5-5-6-5x =28				

Rails 770–778, Mill E; 780–782, Mill D; 760–768, Mill E; 789–796, Mill D.
R = Loading block pinched sides of head.
U = Rail unbroken. Twisted.
NB = Not broken.

TABLE 7(B)

COMPARISON OF DROP AND BEND TESTS ON "A" RAILS

Supports on 4-ft. centers. Central loading. Drop tests at mill

Lab. Rail No.	Drop Test Data—Head-Up: Blows for Failure	Permanent Set, in. Blow 1	Elongation percent	Bend Test Data—Head-Down: Maximum Load, lb.	Deflection, in.	Energy for Failure ft.-lb.	Elongation percent
			112-lb. Rails				
769	5	0.90	5–6–9–10x–11–10 =51	268,400	3.81	71,500	6–10–14–17x–12–9 =68
771	5	0.90	9–10–9–8–7x–5 =45	268,100	3.23	58,500	6–9–11–12x–11–6 =55
773	6 NB	0.90	6–7–9x–11–11–10 =54	264,700	3.72	69,000	6–9–14–15x–12–8 =64
775	5	0.90	7–9–8x–8–7–7 =46	260,900	3.13	55,500	8–10–13–15x–10–9 =65
777	5	0.95	6–7–8–8x–9–7 =45	272,700	4.08	80,100	8–11–17–20x–14–10 =80
779	5	0.80	7–8–9x–11–10–8 =53	284,400	2.98	59,500	8–10–12x–10–8–6 =54
781	4	0.95	5x–6–7–6–5–5 =34				
783	5	0.85	7x–8–9–9–8–7x =48	284,700	2.31	42,000	4–5–7–7–7x–4 =34
786	4	0.85	6x–7–8–8–8–7x =44	273,000	2.55	45,800	6–7–9x–6–6–6 =40
787	5 NB	0.80	9–10–10x–9–8–7 =53				
			131-lb. Rails				
759	6	0.80	7–9–11–9–9–8x =53	338,300	3.62	85,300	8–10–15x–16–12–10 =71
761	6	0.90	7–9–11–12x–13–11 =63				
764	4	0.85	6–8–8–9–9x–8 =48	325,300	2.77	58,200	5–6–10–10x–7–6 =44
765	5	0.85	8–11–13x–14–13–11 =70				
767	7	0.80	11–12–13x–12–11–8x =67	327,600	3.89	89,200	8–11–14x–14–12–8 =67
791	5	0.75	7x–7–8–8–7–6 =43	347,600	3.41	82,800	5–8–11–15x–13–10 =62
793	5 P	0.70	5x–6–6–6–5–5x =33	361,800	3.09	76,800	6–9–11–16x–10–8 =60
795	5	0.75	6x–7–8–8–8–7x =44	368,600	2.92	72,300	6–10–14x–10–8–6 =54
797	5	0.75	6–7–8–8–7–6x =42	277,900	1.02	16.340	2–2–3–4–4x–2 =17
798	4	0.70	5–6–7–7x–6–5 =36	282,500	0.84	13,300	1–2x–1–1–2–1 = 8

Rails 769–777, Mill E; 779–787, Mill D; 759–767, Mill E; 791–798, Mill D.
NB = Not broken.
P = Pipe.

TABLE 7(C)

COMPARISON OF DROP AND BEND TESTS ON "A" RAILS

Supports on 4-ft. centers. Central loading

Lab. Rail No.	Drop Test Data: Blows for Failure	Drop Test Data: Permanent Set, in. Blow 1	Drop Test Data: Elongation percent	Bend Test Data: Maximum Load, lb.	Bend Test Data: Deflection, in.	Bend Test Data: Energy for Failure ft.-lb.	Bend Test Data: Elongation percent
			131-lb. Rails Head down				
799-2				364,300	3.61	91,000	5-8-14-18x-13-8 =66
800-2				367,700	3.55	89,100	7-9-12-13x-10-8 =59
801-2				359,300	3.56	88,700	8-12-14-14x-9-6 =63
802-2				361,500	2.97	70,500	5-8-11-12x-7-6 =49
803-2				363,100	3.45	85,200	9-11-19x-13-10-7 =69
804-2				363,000	3.50	87,600	6-10-15x-14-11-7 =63
			Drop Tests at Mill				
			131-lb. Rails Head-up				
799-1	1F	Broke	2-2-3-3-2-2x =14	382,300	2.52	61,800	3-4-8x-5-5-4 =29
800-1	6	0.70	7x-8-9-8-7-5x =44	409,500	4.85	143,000	9-12-18x-12-12-10 =73
801	1U	0.70	Rail Unbroken				
802	1U	0.70	Rail Unbroken				
803-1	6	0.75	5-7-9-10-9x-8 =48	397,600	4.63U	134,900	10-11-11-11-10-10 =63
804-1	1F	Broke		415,400R	4.74	137,000	7-10x-14-14-13-10 =68

All rails were from Mill I.
F = Failed in mill drop test.
U = Unbroken.
R = Loading block pinched side of head.
Rails 802 and 804 segregation in web.

TABLE 7(D)

COMPARISON OF DROP AND BEND TESTS ON "A" RAILS

Supports on 4-ft. centers. Central loading

Lab. Rail No.	Drop Test Data: Blows for Failure	Drop Test Data: Permanent Set, in. Blow 1	Drop Test Data: Elongation percent	Bend Test Data: Maximum Load, lb.	Bend Test Data: Deflection, in.	Bend Test Data: Energy for Failure ft.-lb.	Bend Test Data: Elongation percent
			131-lb. Rails Head-up				
755 H	2	0.74	3–3–4x–3–3–3 =19	375,900	3.88	98,700	7–8x–8–8–7–6 = 44 125,25
756 H	6	0.78	7–9–9–9–7–6 =47	353,000	3.76U	91,730	10–12–12–12–10–8 = 64 70,50
757 H	2	0.74	3–3–3–4x–3–3 =19	367,900	2.44	57,200	110,40
758 H				368,700	4.00	107,800	8–9–10–10x–9–6 = 52 78, 7
1037							
1043							
1050	6	0.70	7–7–10x–7–8–5 =44	393,000	5.53	153,500	11–15–13x–15–11–7 =72
1053	6	0.75	5x–7–7–8–10–9 =42	384,100	5.06	137,500	7–10–15x–12–11–11 =66
1068	7	0.76	6–7–11–12–16x–12 =62				
1075							
1087	6	0.71	8–8–6–6–3–5x =36				
1095	7	0.73	7–8–9–8–8–6 =46				
1099							
1101							
1108	6	0.75	6x–6–8–8–8–7 =43	378,500	4.53U	122,700	8–10–12–12–11–9 =62

Rails No. 755–758, Mill D; 1037–1053, Mill B; 1068 & 1075, Mill E; 1087–1108, Mill I.

H = Rails 755, 756, 757 and 758 are from a hydrogen-treated ingot. The numbers of longitudinal and transverse shatter cracks found on one side of a 6-in. horizontal slice from the rail head were as follows: 755, B rail; 125L, 25T: 756 E rail; 70L, 50T: 757, A rail; 110L, 40T: 758, C rail; 78L, 7T.

U = Unbroken; T = Transverse shatter cracks; L = Longitudinal shatter cracks.

TABLE 7(E)

COMPARISON OF DROP AND BEND TESTS ON "A" RAILS

Supports on 4-ft. centers. Central loading

Lab. Rail No.	Drop Test Data: Blows for Failure	Drop Test Data: Permanent Set, in. Blow 1	Drop Test Data: Elongation percent	Bend Test Data: Maximum Load, lb.	Bend Test Data: Deflection, in.	Bend Test Data: Energy for Failure ft.-lb.	Bend Test Data: Elongation percent
			131-lb. Rails Head-down				
755				341,500	2.61	55,300	4–5–6–7–7x–4 =33H
756	4	0.81	8–12–15–17x–14–11 =77	331,400	2.99	67,600	6–6–9–10x–9–8 =48H
757	2	0.75	2–3–4x–6–4–4 =23	349,600	2.41	55,500	6–7–7–9x–7–5 =41H
758				331,700	2.26	48,400	4–8x–6–6–5–4 =33H
1037				332,500	4.17	100,800	10–14–21–23x–15–9 =92
1050	5	0.71	7–13–16–18x–13–10 =77	351,900	3.64	90,100	9–14–18x–16–11–7 =75
1053				343,400	4.06	99,400	8–15–21x–20–14–8 =86
1068	2	0.80	3–6–7x–6–7–6 =35				
1087	5	0.76	12–16–22x–16–11–6 =83	351,800	3.68	91,000	10–14–20x–16–12–8 =80
1095							
1101				341,800	3.60	87,100	8–10–17–18x–13–8 =74
1108	5	0.77	10–15–17–19x–13–10 =84	339,500	3.78	91,200	10–14–18x–15–11–7 =75

Rails 755–758, Mill D; 1037–1053, Mill B; 1068, Mill E; 1087–1108, Mill I.
H = Rails 755, 756, 757 and 758 are from a hydrogen-treated ingot.

Fig. 11.—Etched Cross-Section of Rail, No. 797.

(text continued from page 626)

less than 25 percent of the value obtained for other rails. The elongation values are also extremely low. Fig. 11 is a photograph of the etched cross-sections of Rail 797, the section being taken from near the fractured end of the specimen. A segregated condition is present extending well up into the head detectable only in the head-down bend test.

Table 7 (c) shows the results on rails from two heats from Mill I. Rails 799, 800 and 801 are from one heat. Rail 799, from the second ingot, failed under the mill drop test. The head-up bend test specimen cut adjacent to the failed drop test specimen gave good values of energy and elongation as did the head-down specimen from the next cut. Fig. 12 is a photograph of an etch test piece cut from the front end of the first bend specimen. The segregation does not extend quite as far into the rail head and does not have an adverse effect upon the properties as revealed in the bend test.

Rail 804 from the second heat, ingot 17, also failed in the mill drop test but gave good bend test values.

Fig. 12.—Etched Cross-Section of Rail, No. 799–1.

Tables 7 (d) and (e) show results on 131-lb. rails which have been on hand at the Talbot laboratory for several years. Many special tests have been made on these rails as long lengths were available and it is reasonably certain that no unusual conditions are present as they are from the B, C, D and E ingot positions.

Rails 755, 756, 757 and 758 are of particular interest as they are from a hydrogen-treated ingot and badly shatter cracked. These rails give passable drop test values and good bend test values although the elongations in the drop test on the "A" and "B" rails are very low. In this case neither type of test, head-up or head-down, served as a reliable detector of shatter cracks.

VI Acknowledgments and Plans for Future

11. **Advisory Committee and Test Party.**—The present members of the advisory committee for the Rails Investigation are as follows:

Association of American Railroads—Rail Committee:

W. H. Penfield, Chief Engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad (Chairman)
J. E. Armstrong, Chief Engineer, Canadian Pacific Railway
W. C. Barnes, Engineer of Tests, Rail Committee, AREA
C. B. Bronson, Inspecting Engineer, New York Central System
E. E. Chapman, Mechanical Assistant to Assistant to Vice-President, Atchison, Topeka & Santa Fe Railway
H. R. Clarke, Engineer Maintenance of Way, Chicago, Burlington & Quincy Railroad
G. M. Magee, Research Engineer, Engineering Division, AAR
P. Petri, Chief Engineer Maintenance, Baltimore & Ohio Railroad
Louis Yager, Assistant Chief Engineer, Northern Pacific Railway

Rail Manufacturers' Technical Committee

L. S. Marsh, Manager, Department of Inspection and Metallurgy, Inland Steel Company (Chairman)
F. W. Bendell, Manager, Railroad Materials and Commercial Forgings Bureau, Chicago District, Carnegie–Illinois Steel Corporation
O. U. Cook, Assistant Manager, Department of Metallurgy, Inspection and Research, Tennessee Coal, Iron & Railroad Company
E. F. Kenney, Metallurgical Engineer, Bethlehem Steel Company
J. H. Reece, Chief Inspector, Colorado Fuel & Iron Company
F. A. Wickersham, Assistant to Chief Metallurgical Engineer, Carnegie–Illinois Steel Corporation.

The contact committee, a small body appointed from the advisory committee, is as follows:

L. S. Marsh, *Chairman*	C. B. Bronson	E. F. Kenney
W. C. Barnes	E. E. Chapman	G. M. Magee
F. W. Bendell	O. U. Cook	

Acknowledgment is made of the great value of the services of these committees. Not merely have they served to correct errors of statement and improved the form of presentation but the members have suggested many ideas which have been of value in planning and carrying out the investigation.

The present test party includes the following:

H. F. Moore, Research Professor of Engineering Materials, University of Illinois, in charge of investigation
R. E. Cramer, Special Research Assistant Professor of Engineering Materials, metallurgical work, including field tests of cracked end-hardened rails, and mill-cooling tests
N. J. Alleman, Special Research Assistant Professor of Engineering Materials, rolling-load tests, bend and drop tests, field and batter tests of rails
R. S. Jensen, Special Research Assistant, field tests of batter of rails, laboratory tests
Student Assistants: William Mareneck, P. A. Ramsdell,

Mechanicians: M. K. Shafer, Harley Musgrove, both on part time
Assistant in Machine Shop: Marion Moore
Clerk and Stenographer: Rogene Strode

12. **Plans for 1942.**—The plans for 1942 are necessarily subject to modification in view of the war situation. They may be summed up in one sentence: There is planned further study of actual temperature conditions in control-cooling containers at steel plants, especially during cold weather, further study of results of the field tests for batter at Carey, Ohio, and the development of the bend test for rails.

13. **Acknowledgments.**—At this time special acknowledgment is made of the services of Mr. I. C. Mackie, Engineer of Tests, Dominion Steel & Coal Corporation, Sydney, Nova Scotia. Throughout the tests, Mr. Mackie has been of very great help to the investigation. In 1933 he furnished the test party the first control-cooled rails with the companion air-cooled rails. Through his efforts the test party was allowed to spend three weeks at the Sydney mills and to conduct experiments on hydrogen-treated rails. His comments on the results and work of the Rails Investigation, have been kindly and helpful.

Acknowledgment is made of the hearty and active cooperation of each of the rail mills at which tests have been made,—the Carnegie–Illinois Steel Corporation, at Gary, Ind. and the Edgar Thompson mill at Braddock, Pa., the Colorado Fuel & Iron Corporation, at Pueblo, Colo., the Tennessee Coal, Iron & Railroad Company, at its Ensley mill, Birmingham, Ala., the Inland Steel Company, mill at Indiana Harbor, Ind., and the Bethlehem Steel Company mills at Steelton, Pa. and Lackawanna, N. Y.

Appendix

A Study of the Drop Test For Rails

By H. F. Moore and N. J. Alleman

14. **General Features of the Drop Test.**—The standard drop test for railroad rails is a "pass or fail" test, and it does not give any quantitative evaluation of the strength, ductility or toughness of the rail or of the metal in it. The energy for bending or breaking the rail specimen is furnished by a weight (tup) of 2,000 lb., falling a distance of 16 to 22 ft., depending on the weight of the rail. Neglecting the small additional drop due to the deflection of the rail and friction of guides, under the first blow the total kinetic energy developed in the falling weight is 44,000 ft.-lb. for the heaviest rail tested, 131 lb. per yd. Of this energy some is used in deflecting the springs which support the anvil of the standard M.C.B. drop-testing machine for rails. In the machine used at the University of Illinois the energy required to "close" the 12 springs is about 4,400 ft.-lb. and the springs close under the blow of the 2,000-lb. weight falling a distance of 12 ft. on a plate of steel resting directly on the anvil. This indicates a loss of energy in other ways than in the springs.

Under a 22-ft. drop on a rail the loss of energy would not be less than the 4,400 ft.-lb. required to close the springs. This would leave not more than 39,600 ft.-lb. for breaking or bending. Comparisons of drop test data and bend test data, which will be discussed later, indicate that under a load which gives the same permanent deflection as the first blow of the drop test, the energy which bends the rail is about 37,000 ft.-lb. of which about 7,400 ft.-lb. is recovered by elastic spring-back. Probably the exchanges of

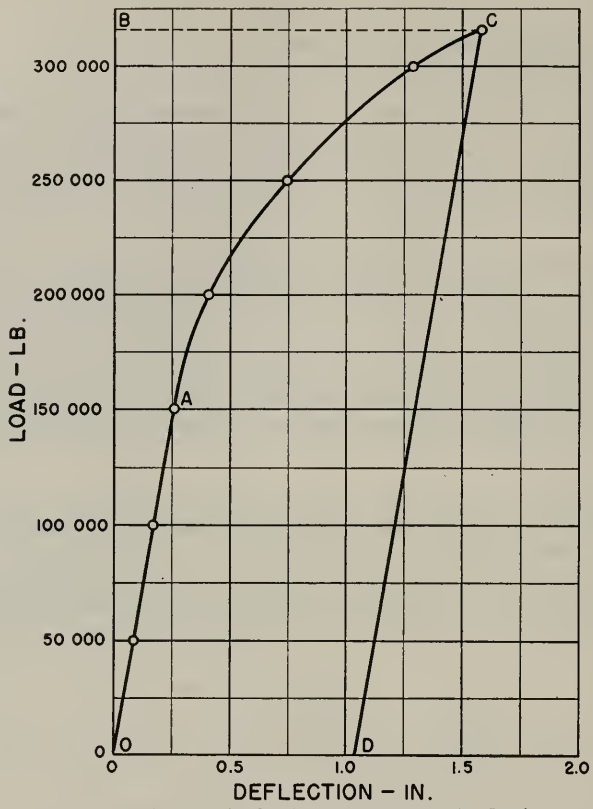


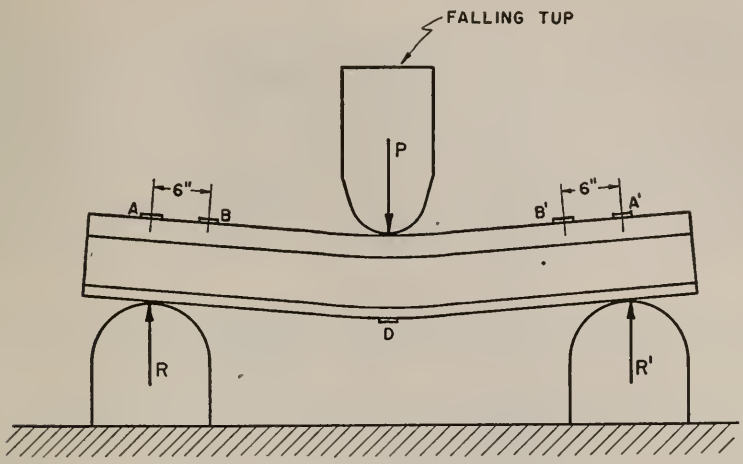
Fig. 13.—"Force of Blow" by Permanent Deflection.
Bend test on rail 1053 head up.

energy between the springs and the rail, the elastic spring-back of the rail and the waves of stress set up in the rail complicate the problem of the amount of energy which actually reaches the rail specimen. However, it seems evident that the available energy for breaking a 131-lb. rail specimen in one blow is decidedly less than 44,000 ft.-lb.

Since the first blow of the drop test rarely breaks the rail specimen but does close the springs under the anvil, it is impossible from the data available to get any reliable direct comparison of the energy required to break the specimen under the drop test and under the bend test.[1]

15. **"The Force of a Blow."**—The question is often raised, "What is the 'force of the blow' in the drop test"? This question cannot be directly answered. The *energy* of the falling weight at the instant when it strikes the rail is known, neglecting the slight friction on the guides. The *force* exerted during the bending (or the breaking) of the rail depends upon; (1) The energy absorbed in the rail, mainly by plastic action, (2) the energy used in accelerating the anvil downward, (3) the energy spent in com-

[1] In the bend test the energy for fracture is measured by the area under the complete load-deflection diagram.



ANVIL OF M.C.B. DROP TESTING MACHINE

Fig. 14.—Diagram of Apparatus for Determining the "Force of Blow" in the Drop Test.

pressing the springs under the anvil, and (4) energy lost in vibrations, friction of parts, hammer rebound, etc.

Three methods of study have been used to determine an approximate static load which would produce the effects shown after the first blow in the drop test.

16. **Measurement of "Force of the Blow" by Permanent Deflection.**—After the first blow in the drop test the permanent deflection remaining is measured by means of a steel scale and a 48-in. bar. The mills use a 3-ft. bar for measuring this deflection. In the tests at the University of Illinois both the 3-ft. and 4-ft. bar are used.

The bend test shows a load-deflection diagram like that shown in Fig. 13 and companion bend tests and drop tests are made from pieces of the same rail. The permanent deflection observed in the drop test, *OD* in Fig. 13, is laid off as shown, and the line *DC* is drawn parallel to the line *OA* in the load-deflection diagram. If the load had been released from *C* it would have followed the line *CD* quite closely. (As a matter of fact, in several special tests it did so). Then *OB* represents the force which would have caused the set produced after the first blow of the drop test, and in a rough way *OB* may be regarded as the "force of the blow" on that particular specimen on that particular machine. Results of tests by this method are shown in Table 8.

17. **Measurement of Force of Blow by Measurement of Permanent Elongation in Bottom Fiber of Rail at Mid-Span.**—In several special tests a DeForest scratch extensometer was attached to the bottom of the drop test specimen as shown at *D* in Fig. 14. This extensometer has a gage length of 2 in. After the first blow of the drop test the maximum and the permanent elongation along the 2-in. gage length were measured on the scratch diagram. The permanent elongation was checked by the use of a Berry 2-in. strain gage. In the companion bend test a scratch extensometer was attached in the same relative position, and the load was released when the total deflection on the autographic diagram reached the value represented by *BC* in Fig. 13. Four

TABLE 8

STATIC LOAD REQUIRED TO PRODUCE PERMANENT DEFLECTION EQUIVALENT TO DEFLECTION OF FIRST BLOW IN DROP TEST

Supports on 4-ft. centers. Falling tup and static load applied at mid-span. 131-lb. rails. Weight of tup 2,000 lb. Drop height 22 ft.

Rail No.	*Head or Base Up*	*Drop Test Results*		*Bend Test Results*		*Load lb.*	*Total Energy ft.-lb.*	*Spring-back Resilience ft.-lb.*
		Permanent Deflection		*Permanent Deflection*				
		3-ft. bar	*4-ft. bar*	*3-ft. bar*	*4-ft. bar*			
789	Head	0.75	----	0.75	1.05	346,000	38,800	8500
1050	Head	0.70	0.94	0.68	0.94	319,300	35,700	7700
1053	Head	0.75	1.02	0.74	1.00	317,000	37,700	7500
1087	Base	0.76	1.01	----	1.01	318,000	29,100	6600

pairs of companion tests were carried out and in each of these the set remaining after the load *OB* was released was very close to the permanent elongation as found in the drop test. The load then corresponds to *OB*, and this load may be regarded as the static load equivalent in its effect on set to the first blow of the drop test.

This second method of measuring the "force of the blow" is virtually a modification of the first method. In addition to giving a measure of the load necessary to bend the rail it indicates that there was no noticeable "speed effect" on elongation in the drop test since the maximum elongations in the drop and bend tests check each other closely, as do the permanent elongations. Results of tests by this method are shown in Table 9.

TABLE 9

STATIC LOAD REQUIRED TO PRODUCE ELONGATION IN BOTTOM FIBER OF RAIL EQUIVALENT TO THAT PRODUCED BY THE FIRST BLOW OF A DROP TEST

131-lb. rails tested head-up on a 4-ft. span. Scratch strain gages with 2-in. gage length attached to center line of base of rail at mid-span. Readings of Berry strain gage taken over same gage line.

Rail	*Elongation of Bottom "fiber" percent*		*Type of test*	*Static Load to cause approximately the same elongation as the first blow of the drop test lb.*
	Maximum under Load	*Permanent after Load*		
1053*	3.39**	2.66**	Bend	317,000
1053*	----	2.73***	Bend	317,000
1095*	3.44**	2.59**	Drop	-------

* Brinell tests on rails 1053 and 1095 showed 249 and 251, respectively.
** Test with DeForest scratch extensometer.
*** Test with Berry strain gage.

18. Determination by Means of Elastic Strain Near the Supports of the Rail.—A scheme for making an approximate determination of the force with which the falling tup of the M.C.B. drop-testing machine strikes the bend test specimen has been devised, and some preliminary try outs of the apparatus used give promising results.

Fig. 14 shows the apparatus in diagram. To the top surface and the bottom surface of the rail specimen are attached DeForest scratch extensometers *A*, *A'*, *B* and *B'*. These scratch extensometers measure the strain at the top surface of the rail specimen at the locations indicated.[2] The scratch extensometers *A*, *A'*, *B* and *B'* are on the upper surface and are located where the steel is not stressed beyond its elastic range (as shown by approximate computation and by trial),[3] and therefore the *change* of strain between *A* and *B* or between *A'* and *B'* gives us the means of computing the change of bending moment, and hence the equal reactions *R* and *R'* and the load *P*.

[2] DeForest scratch extensometers were used rather than strip gages on magnetic strain gages for three reasons: (1) the scratch extensometers near the middle of the span will show plastic strain, which would go beyond the range of most strip or magnetic strain gages, (2) Dr. R. N. Arnold in his tests of rail steel in a smaller drop testing machine found the scratch gage simple and reasonably accurate, and (3) at the present time strip gages are not available. It is hoped that later strip gage measurements may be made at locations *A*, *A'*, *B* and *B'* where the strains are within the elastic range of rail steel.

[3] At the quarter span the base is still elastic although the surface of the head has passed the elastic stage.

TABLE 10

DETERMINATION OF "FORCE OF BLOW" BY MEANS OF ELASTIC STRAIN NEAR THE SUPPORTS OF THE RAIL

Rail 1095, 131-lb. section tested head-down. 22-ft. blow. Gages mounted on rail base

Drop, Height ft.	*Bending Moment 6 in. from Support in.-lb.**	*Reaction Load, lb.*	*Equivalent Static Load at Mid-Span, lb.*
2	893,000	149,000	298,000
5	904,000	151,000	302,000
22	1,079,000	180,000	360,000

* Average of the two readings at B and B′, Fig. B.

It might be expected that the strain at A and A' would be zero, the specimen acting as a simple beam with no bending moment at the supports. This is true for the bend tests, but in the drop test owing to the inertia of the rail specimen there is a small negative bending moment at A and A'.[4]

However, it seems unlikely that the negative moment at A and A' occurs at the same instant when the maximum positive moment at B and B' occurs. The reason for a negative moment at A, Fig. 14, is the inertia of the rail end. It seems probable that this inertia moment would be a maximum when the rail began to bend, and that when the first blow was nearing completion the bending of the rail would be largely plastic and slower than at the first contact of tup and rail, and that the acceleration of the rail end at A would have diminished nearly, if not quite, to zero. It is assumed then that the negative moment at A may be neglected and that the moment at B may be determined from the strain shown by the scratch extensometer, B, the known modulus of elasticity of the steel and the section modulus (I/c) of the rail. This moment then equals 6 times the reaction R or R', and the equivalent "force of the blow" may be placed at $2R$. Table 10 shows values of this "force of the blow" obtained by this method for drops of 2 ft., 5 ft., and 22 ft.

It is to be noted that the different methods give results which do not differ widely, especially in view of the probable differences of properties of the steel in the different rails. The test using three heights of drop indicates that the force applied to the rail was built up very rapidly, probably before the elastic strength of the specimen is reached, and comparing drop test results in Table 10 would indicate that the first blow of a drop test must stress a rail rather close to its ultimate strength,[5] but that the energy supplied in the 22 ft. fall is not sufficient to complete the fracture.

[4] In the Seventh Progress Report of this investigation the footnote to Conclusion 1, Section 16, Chapter III, discusses this point, which was noted by Dr. R. N. Arnold in his tests.

[5] Bend tests (head-up) of 131-lb. rails showed values of ultimate load ranging from 351,900 lb. to 415,400 lb.

PROCEEDINGS

A

PROCEEDINGS

Report of the opening session of the meeting on Tuesday morning, March 17, 1942; the closing session on Thursday afternoon, March 19; and other business not related to the presentation of the committee reports

Address of President F. L. C. Bond
Address of Andrew Stevenson
Address of Joseph B. Eastman
Report of the tellers
Address of Dr. H. J. Cody

Opening Session, Tuesday Morning, March 17, 1942

The forty-third annual meeting of the American Railway Engineering Association was called to order at 10:00 a. m., on March 17, 1942, in the Grand Ball Room of the Palmer House, Chicago, by President F. L. C. Bond, vice-president and general manager, Central Region, Canadian National Railways, Toronto, Ont.

President Bond: This is the forty-third annual meeting of the American Railway Engineering Association, and it is now declared open for business. This meeting is also the concurrent session of the Construction and Maintenance Section—Engineering Division, AAR.

The first order of business is the reading of the minutes of the last annual meeting. Inasmuch as these minutes have been printed and a copy has been furnished to each member, unless there is objection, the reading of the minutes will be dispensed with. As there are no objections, the minutes will stand as printed.

Address of President Bond

In opening the forty-third annual meeting, we are assembled under a stress of circumstances which compels every member of our Association, and also of our profession, to regard his civil responsibilities as national service, and his regular sphere of duty as his "Action Station."

Our Association has earned a reputation for high achievement. The basis for its success is an extraordinary system of voluntary cooperative effort, which has become so well established as to constitute a pattern for committee work which is transmitted to each succeeding group of committee members.

Because of this, the Association possesses a high degree of "going concern" value, which constitutes a substantial reserve on which to draw during difficult times. I do not wish to infer that we have had to depend upon stored up energy for our accomplishments during the past year, although there were many distractions far beyond control.

Notwithstanding this, the year's work has been well done by the standing and special committees, whose reports are about to be presented for our consideration.

In terms of the membership record, we are holding our own. Circumstances are far from favorable for an increase in numbers, but we must continue our efforts to make good the natural process of depletion in our ranks.

We are fortunate in having a satisfactory addition to the number of our junior members, considering the response which is being made to the demands of the fighting services. All junior members will be well advised to qualify themselves for assignments on the working committees, and derive the benefits from the opportunities so freely offered for training in their life vocation, which will enable them to stand well equipped to serve the needs of the hour and the unprecedented demands which will follow on the heels of the present turmoil.

Financial Condition Sound

The financial report for the last year shows a substantial excess of receipts over expenditures; our cash position was such that we invested $10,000 of the Association's funds in United States Defense Bonds. On the other hand, a coincidence which required us to undertake two separate and rather large republication commitments at the same time, will result in larger and exceptional outlays during the present year.

As pointed out in the report of the secretary, the outcome of our financial operations is dependent in nearly every year upon the size of our printing bill, and our primary opportunity to effect economies will be found in controlling this item. Our work must continue and there are many vital problems to be dealt with, but I am sure our committees will find it possible to present the essential facts, together with the conclusions reached, in appropriate size and serviceable form. There is nothing new in this suggestion, as a glance at a set of the AREA Proceedings over a number of years will show fluctuations in the volume, but not in the value of the reports.

The Manual

In this connection, special mention should be made of our Manual of Recommended Practice. In 1936, after considerable expenditure, the Manual was placed at your disposal, in its present loose-leaf form. This was an experiment, to the extent that the financial results were not predictable, and the expense of maintaining the Manual up-to-date in this form has been somewhat burdensome. Perhaps the most important source of unexpected expense is to be found in a disposition to find new material, and to refine the material already adopted, with the result that the cost of issuing annual supplements is sometimes unduly excessive. We should, therefore, guard against duplication of work of other associations, and possibly we could give more time to the "refining" of our specifications before they are presented for adoption, to avoid doing so at a later date.

Thanks to the continued support received from the Association of American Railroads, our committees have been aided greatly in their studies by the results of investigations and tests carried out by a competent research staff. Furthermore, the renewal of the research appropriations from year to year has assured the continuation of this important work on a well organized basis. The amount authorized for 1942 is somewhat less than for the preceding year, but is in accordance with our considered appropriation request.

Change in Research Organization

A turning point was reached in our research work during the past year through the retirement of Dr. A. N. Talbot, chairman of the Committee on Stresses in Track, after 27 years of outstanding and distinguished service. This occasioned a complete recasting of the organization.

Because of leave of absence granted to members of the staff for military service (including three reserve officers), our depleted personnel was moved to the AAR offices in Chicago, where they joined other research workers of the Engineering Division in a consolidated organization under the administration of Mr. Magee, the research engineer, which has proved a commendable arrangement.

It is not to be inferred that we have severed our relations with the University of Illinois, which has served as the headquarters from which so much valuable scientific work has been directed in determining the behavior of track and structures under load. The arrangements for the cooperative investigation of rails is being continued under the direction of Professor Moore and a new agreement has been entered into between the AAR and the university, for two projects, involving the extensive use of rolling-load machines in the study of rail joints, and the relation of wheel tread to rail contour.

The participation of the AAR in the joint investigation of fatigue strength of structural welds, will be continued throughout the year.

Our Association has not failed to record in permanent form its profound sense of gratitude to Dr. Talbot for his devoted and invaluable services, extending over a long period of years. This tribute, in the form of a suitable bronze tablet, has been erected on the wall of the Materials Research Laboratory at the university, now appropriately known as the Arthur Newell Talbot Laboratory. The dedication of this tablet took place on November 21, 1941, at which our Association was well represented.

The Outlook

In my opening remarks I made reference to the limitations imposed on the Association by reason of wartime conditions. While it is true that our original objective and plan of procedure has been based on rendering service to the railways in normal times, nevertheless it is probably more than a coincidence that this Association was brought into being in 1899, or immediately after the shortcomings of the railways were brought into sharp relief during the Spanish-American war. However, such progress was made by the Association in the ensuing years that, from the outset of the first World War, we were able to offer much that was of direct military value.

Thus it seems that, whereas the war necessarily affects the activities of the Association, its usefulness and adaptability to meet the requirements, makes us part of the war machine. Possibly the first evidence of this in the present situation, was the marked increase in the demand for the Manual, and there can be no better evidence of the recognition of our recommended practices.

Nature of the Service

On the whole, the service which the AREA must perform is something which it does efficiently but unobtrusively; it serves as the reservoir from which to draw qualified personnel for advisory technical committees, usually to perform some special service on short notice. Recently, one such committee has been formed to consider temporary revision of specifications for track material; another is engaged in an emergency study of ways and means for reducing the consumption of rubber; one of our regular committees was asked to arrive at a prompt conclusion as to the effects of restrictions on the use of soda ash in the treatment of water.

The temporary revisions of the specifications for track materials just referred to, were undertaken at the instance of the War Production Board, which has created an organization to develop "National Emergency Steel Specifications." The object of such revision is to step up production and relieve certain critical conditions.

An Unusual Procedure

Emergency action of this nature will not permit of the usual prescribed procedure, on account of time limitations. Accordingly, your Board of Direction has adopted an exceptional course of action and has authorized emergency revisions of matter in the Manual, upon affirmative letter-ballot of the interested committees.

Revisions so authorized will be effective only for the "duration" and are to be published as colored sheet riders on the documents they modify. None of these changes will be made in the actual sheets of the Manual unless approved by the Association in accordance with regularly authorized procedure.

These are a few illustrations of what must be expected in constantly increasing measure, and we fully realize that we are confronted with an entirely new set of conditions, but which we stand prepared and qualified to deal with.

This attitude is equally important with respect to the regular assignments of our standing committees; the work must go forward. We must keep on with those continuing studies which lead to distinct improvements in the service of the railroads, under all conditions. Nevertheless, and in complete accord with all institutions throughout the Allied Nations, we will assuredly and vigorously dedicate our entire talent and resources toward the one primary and paramount objective—to win the war. (Applause)

President Bond: The next order of business is the report of the secretary and the treasurer. I will ask Mr. Lacher, the secretary, to present these reports.

Secretary's Statement

Secretary Lacher: The reports of the secretary and the treasurer are necessarily of a statistical nature and, for that reason, are not very interesting reading. (See pages 671–680)

I have tried this year, as I have in the past, to take off the curse by making the report as short as possible; and, in addition, I have attempted each year to include something a little different—to stress some phase that I have not mentioned before. I hope some of you will read it. Judging from the criticisms received, at least a few of you do read it.

It occurs to me that perhaps I might give you a few round figures that you might keep in your minds, that represent in a general way the fiscal operations of the Association. For example, we have just short of 2,000 members, and, collecting on an average of about $10 apiece from them, we have revenues from our membership account of $20,000 or thereabouts.

We also collect 50 percent, or in the neighborhood of $10,000, from other sources, thus bringing the total revenues of the American Railway Engineering Association to approximately $30,000.

In addition, a fact that is probably not very well known is that the AAR provides us with in the neighborhood of $9,000 to pay half of the salaries of the secretary and his staff, and certain incidental expenses of the conduct of the office so that we have in the neighborhood of about $39,000 to spend, although that $9,000 is kept entirely separate and is not shown in the treasurer's accounts that you will find summarized in this report.

As a rule, the finances of the Association are so handled that we can show a modest excess of revenues over expenditures, with the result that through the years the Association has accumulated in the neighborhood of $90,000. Perhaps you wonder why

it is necessary for the Association to have such a surplus. That might be argued various ways, but it is a matter of interest that of our total revenues about $2,000 represents the interest derived from those funds..

During the year ending December 31, 1941, the Association accumulated an excess of about $3,000 over the expenditures. However, this coming year, owing to heavy expenditures for our publication work, as explained by your president, we will probably run behind as much as $3,000.

Turning now to the membership, you will find, as reported in detail in the report, that effective March 1 of this year, we had 34 more members than we did March 1 a year ago.

There is one point I want to bring out now, which I failed to mention in the printed report, namely, that the Canadian membership has increased by 4 during the year; and, in comparison with the total membership of Canadians in the Association, that probably represents an appreciably larger percentage of increase than the percentage of increase among those living in the United States.

I want to call attention to the fact that it is very necessary for us to take in a considerable number of new members each year. On the average, it requires about 100 new members simply to offset the losses due to deaths, resignations or other causes.

The one part of the report that is obviously deficient is the statement with respect to the number of members in military service. We have been able to record only such cases as have come to our attention, and undoubtedly there are a great many other members in the armed forces of the United States and Canada who have not notified us. They have had more important things on their minds than that. But my associates and I in the office will appreciate it very much if each of you will take it upon yourselves to notify us of any of your friends or associates who have entered military service.

The same thing applies to the membership list as a whole. No membership list is ever accurate. As an illustration, I wish to point out that between the time we sent the final proofs to the printer and the printer did his work and sent us copies, changes occurred that required ten corrections in the membership listings. So we would appreciate your help in that respect.

President Bond: Gentlemen, you have heard the reports of the secretary and treasurer. What is your pleasure? If there is no objection, they will be accepted as printed.

I am sorry to have to announce that Mr. Buford, the vice-president of the Operations and Maintenance Department of the AAR, has just wired us to the effect that conditions which have developed in Washington make it impossible for him to be with us in Chicago this morning.

Remarks on Thursday Morning, March 19, 1942

Vice-President Clarke (in the chair): I regret to say that Dr. Talbot suffered a heart attack Tuesday night, but is reported to be resting comfortably at Passavant Memorial Hospital, where two of his daughters are with him. No visitors are allowed at the present time. I know that you all regret very much that the Doctor has suffered this attack but we are all very glad that it is not more serious than it seems to be at present.

(Dr. Talbot suffered a subsequent attack and died on April 3.)

Report of the Tellers

(Presented Wednesday Afternoon, March 18, 1942)

We, the Committee of Tellers, report the following as the result of the count of ballots:

For President:

H. R. Clarke 915

For Vice-President:

F. R. Layng 904

For Directors (Three to be elected):

G. L. Sitton 458
C. E. Smith 389
R. A. Van Ness 370
A. E. Perlman 316
L. P. Kimball 315
J. E. Teal 314
J. F. Pringle 228
W. B. Irwin 217
John Foley 190

For Members of Nominating Committee (Five to be elected):

L. L. Adams 648
W. G. Arn 614
E. W. Caruthers 580
A. E. Botts 494
G. M. Strachan 438
E. E. Oviatt 401
H. F. King 388
W. J. Hedley 361
D. B. Thompson 335
J. E. Bernhardt 300
Scattering 2

Respectfully submitted,

THE COMMITTEE OF TELLERS,

R. C. Bardwell, *Chairman*
J. F. Bradley
M. J. J. Harrison
A. T. Hawk
C. H. R. Howe
L. J. F. Hughes
E. E. Kimball
C. A. Knowles
J. A. Lahmer
R. A. Morrison
F. E. Morrow
E. F. Salisbury
R. M. Stimmell
R. E. Warden
A. R. Wilson

Closing Session, Thursday Afternoon, March 19, 1942

President Bond: This concludes the presentation of the standing and special committee reports. The next order of business is new business.

E. M. Hastings (Richmond, Fredericksburg & Potomac): I feel very sure it is not necessary for me to call my name as is the custom, nor where I am from.

At the conclusion of this last report we mark the close of the reporting of committee work of a busy year, and we are rapidly drawing to the conclusion of an annual meeting that has been marked by several highlights. It is a meeting I am sure of which your President, Mr. Bond, must be very proud.

Mr. Bond has directed the affairs of this Association through the past year most admirably. He performed a splendid task in the closing months of last year when he took over the reins of the Association due to the untimely death of our friend, George Fanning.

Mr. Bond, we pause at this time in our proceedings of this convention to say just a few things to you, sir, which we feel should be said. You have given to this Association much, and the Association has honored you. But in honoring you, I feel that I express the view of every member of the Association—it has honored itself.

There are certain things, Mr. Bond, that make men great. Those things are, in the minds of some, the accomplishments of men; in the minds of others, they are characteristics that mark them as they walk day by day in their daily life and in their common touch with men. You possess both of those characteristics.

You have honored your profession in carrying on the engineering work which you have carried on. You have honored your friends because of your friendliness and because of your intimate feeling with them, of the real purposes of life.

So I say to you, sir, it seems to me that peculiarly you possess those four things which the great Henry Van Dyke said were so necessary if men were to walk through life and accomplish the things in life that need to be accomplished.

You think without confusion, clearly, and you love your fellow man sincerely, and you act from honest motives purely, and then that highest and greatest of all, we feel and we know that you trust in God and heaven securely.

So this Association, at the close of this annual meeting, wishes to present to you a token, something that you can look at in the years to come and feel that it is indeed a symbol of the high regard and the love which your associates and friends in the American Railway Engineering Association have for you.

I have here the customary bronze tablet inscribed:

"The American Railway Engineering Association presents this tablet to F. L. C. Bond, President 1941–1942, in recognition of the leadership and administrative ability that he applied in directing the affairs of the Association during a critical period."

In handing this to you, Mr. Bond, I wish to say, sir, it is just a further token of the closeness of the people of the United States to the people of the great Dominion of Canada—brothers in arms, friends not only for today but for tomorrow, and allies for Victory! (Applause)

President Bond: Mr. Hastings and Gentlemen: I feel very much embarrassed in that I am totally unable to subscribe to the very kind and generous words which have just been voiced by our friend. I can only say that in trusting me with the guidance and direction of this truly wonderful institution, I was immediately impressed with the responsibility which devolved upon me. It is my humble desire to be of as much service as possible. In that respect I found it easier than I expected, because I was

so ably supported by a Board of Direction of whom I could scarcely speak in sufficiently high terms.

I was ably assisted and directed by the Past Presidents who kindly put their advice and services at my disposal, and which I did not hesitate to draw upon. I think sometimes I wished upon my friend, Mr. Hastings, a few more trips than he would otherwise have liked to make. However, the mission was always in the best of hands; and was always executed with complete satisfaction and success.

I cannot speak too highly of the splendid assistance and helpful guidance which I received at all times from our very able secretary, Mr. Lacher, and to whom both the Association and I are very deeply indebted for his faithful and untiring efforts.

Once more I want to thank you very sincerely for the support you have given us during the past year. What little success, if any, you may have kindly ascribed to me, I can only thank my associates for the support which they have given.

I accept this memento which you have presented to me as a lasting remembrance of the many and enduring friendships which I have been fortunate to find in this body of able, technical and professional associates. Thank you. (Applause)

Armstrong Chinn (Alton): I have a resolution I would like to offer at this time:

"Be it Resolved, That the American Railway Engineering Association, in convention assembled, record its appreciation to Dr. H. J. Cody for his inspiring address at our luncheon meeting in which he traced the origins of the bases of our common civilization and emphasized that its preservation depends upon the ability of the decent nations to stick together in prosecuting the war."

(The resolution was seconded, put to a vote and carried.)

J. B. Akers (Southern): I have a resolution to present:

"Be it Resolved, that the American Railway Engineering Association in convention assembled, extend its appreciation to the National Railway Appliances Association for the constructive exhibit of materials and equipment applicable to the construction and maintenance of railroads, presented concurrently with the convention, which exhibit has added much to the educational value of our meeting."

I recommend the adoption.

(The resolution was seconded, put to a vote and carried.)

F. E. Morrow (Chicago & Western Indiana): I wish to move the following resolution:

"Be it Resolved, That the American Railway Engineering Association in convention assembled, record its appreciation to Joseph B. Eastman for his timely and instructive address before our convention on March 17, clearly explaining the exceedingly vital part that the railroads are taking in the war program of the nation."

(The motion was seconded, put to a vote and carried.)

N. D. Howard (Railway Age): I have a resolution to present before the convention:

"Be it Resolved, That the American Railway Engineering Association in convention assembled, express its thanks to Mr. Andrew Stevenson for his very instructive and valuable address before the opening session of our convention, forcibly presenting information about the methods, procedure and limitations of securing priorities for materials for railway construction and maintenance."

I move the adoption of this resolution.

(The motion was seconded, put to a vote and carried.)

President Bond: Any other new business? It is now my privilege to ask Past President Hastings and Past President Morrow if they will kindly escort President-Elect Clarke to the rostrum.

(President-Elect Clarke was escorted to the platform.)

President Bond: Mr. Clarke, you have been unanimously elected to guide, direct and govern the affairs of this Association for the ensuing year, a year which promises to be one of the most vital and critical in the history of humanity, and in this year this Association must inevitably play an important part.

I don't think it can be stressed too strongly how much the transportation on this continent is involved in conducting the warfare all over the world, and with the transportation we are directly connected as a most important technical body. Not only is it of national import but also of supreme international consequence.

I might say that shortly after the dominion to the north began getting into its stride, I was called to Ottawa to advise upon the nature, the constitution and the personnel of our technical body, which I presumed to represent in the office of President. In answering the questions, I didn't hesitate to say that it was an international body, with headquarters in Chicago, but its personnel drew representatives from many nationalities, some of which we had struck out on account of being alien enemies.

The international feature is once more stressed when our next President, while in every respect a standing citizen of the United States, was born, as he says, in the British Isles, but in that part of the British Isles which is very adaptable to the United States in every way. Once more the international feature, I think, can be stressed for the coming year.

It is my privilege to hand over to you the badge of office with which you can rule, govern and direct the affairs of this Association for the coming year; and I know I am placing it in the very best of hands. (Applause)

(President-Elect Clarke assumed the chair.)

President Clarke: Mr. Bond, Gentlemen: There are times when it is difficult, in fact impossible, to put into words what one is thinking. This is such a time. You have bestowed on me the highest honor that can come to an engineer serving the railroad industry in the construction and maintenance of the fixed property of the roads. I am deeply conscious of this.

In accepting it, I keenly realize the responsibility which devolves upon me. This feeling is greatly increased as I think of the long line of distinguished men to whom each in turn this same feeling has come and who have so ably led the Association through the years, that today it occupies an unchallenged place among professional associations.

The past few years have not been easy. We have found many things which have disturbed the minds of conservative, straight thinking men and, unfortunately, as time passed, the doubt and confusion seemed to become greater.

The events of December 7, 1941, crystallized the thinking of the people and united the nation as it had not been for a long time, but did not make more easy the days that lie ahead. We trust and pray that all America and the nations with which we stand united in the common cause are being ably and wisely led.

Difficult as have been the past few years, we would be well advised to think and plan for days that may be even more difficult. I firmly believe that it is in times such as this that the American Railway Engineering Association can be of the greatest value to the railroad industry and to our country.

If we do not try to see too far into the future but undertake each day the problems that then confront us, with the ability, perseverance and courage which the men of this Association have shown in the past, I am confident we can be of great service.

Knowing the officers, directors and members of the Association, as I think I do, I have no fear that we will fail to measure up to our responsibility and opportunity.

Time necessarily brings changes. We regret the retirement of Past-President Wiltsee and one of our directors, Mr. Akers. They have served the Association ably and well. During the year another director was called from among us, Mr. Smiley. A third director who has served a portion of a term has been re-elected to be with us again.

At this time I wish to recognize the new directors if they are here. I know some of them are not. The new directors are Mr. Sitton, Mr. Smith and Mr. Van Ness. Will these gentlemen please stand, if they are here?

Mr. Smith we welcome you and are glad to have you with us. (Applause)

Will Vice-President Layng please stand (Applause) Mr. Layng, the Board of Direction is happy and the Association is fortunate to have the benefit of your advice again and the right to place responsibility upon you. We welcome you.

I think you have all missed Vice-President Cummings who has not been able to be with us during the meeting. He advances to senior vice-president. Unfortunately, he at this time is ill and in the hospital.

If there is no further business to come before the meeting, the Forty-Third Annual Meeting of the American Railway Engineering Association stands adjourned.

(The meeting adjourned at 4:05 o'clock.)

Annual Luncheon

The annual luncheon of the Association was held in the Grand Ball Room at 12:30 p. m. on Wednesday, March 18, with an attendance of 733 members and guests. After the luncheon had been served, President Bond introduced the guests at the speaker's table and continued as follows:

President Bond: Upon this occasion, which marks the Forty-third Annual Meeting of our Association, it is indeed a privilege and a great satisfaction to welcome so many members, associates and friends of our institution who have come from all parts of the continent to assist in our professional collaboration and to contribute each his quota of knowledge and experience in his chosen field.

This exchange of knowledge is different from any other system of exchange. In commercial fields, one can usually draw benefits only in proportion to his contribution. But in an institution such as ours, one can absorb substantial and lasting values in proportion to all the contributions in the vast field of our professional endeavors and, I might add, significant accomplishments.

But it stands to reason that, in all fairness, every member must assist by contributing, and contributing only his best and surest information, as anything of less value would scarcely stand the test of scrutiny, for which purpose our annual meeting is assembled.

It is always a privilege to welcome those congenial and hospitable spirits who represent the National Railway Appliances Association. Their hearty cooperation at all times is a spur to further progress, whereas their delightful art of embellishing our business relations, and with their unfailing sportsmanship at all times, has won for them an honored place not only in our Association but also in our hearts.

While speaking of our innermost hearts, let me hasten to add that our gathering would present but a crude and somber appearance were it not for the saving grace of the ladies who so kindly favor us with their presence and thus add very materially to those more personal associations which are the basis for our brotherly relations in all our doings.

The general attendance is very gratifying, as we all have occasion to experience the inexorable demands of war which are made especially upon members of our calling, and, we do not wait to be called. Our younger members are particularly well qualified and adaptable to the needs of the armed and the mechanized forces, and gallantly are they responding, whereas our senior members are essential to production and to the direction of those vital lines of communication upon which everything depends, and which we are here to serve.

My only excuse for thus trespassing on your kind indulgence is for the purpose of introducing one of international standing and no stranger in Chicago—Colonel The Honorable and Reverend Dr. Cody—colonel on two counts, the chaplain services and the Officers' Training Corps—"The Honorable", by nature, but technically as a former Minister of the Crown; one who has preached by royal command before His Majesty King George V, of revered memory, and also to the League of Nations at Geneva.

The various honors and awards held by our honored guest would indeed constitute a formidable list, among which may briefly be mentioned, Cavalier of the Legion of Honor (France)—and I mean the France of old, not the poor Vichy-ated remnant of the passing hour. (Laughter and applause) He is also a member of the Order of the Golden Grain from our noble and gallant ally, China. (Applause) Fellow of the Royal Society of Arts (London), Fellow of the Royal Society of Canada. And I omit to make any mention of a decoration which our honored guest handed back to someone called "Musilooney" or some such name. (Laughter)

I might add that our guest has been offered the highest offices in the church, all the way from Nova Scotia to Australia, inclusive; but the University of Toronto has retained its good fortune in having such a guiding and directing head.

Perhaps I have said enough to indicate that we are indeed favored by the presence of a world renowned and revered personage. It might even be more in order to reverse the usual procedure and introduce ourselves to our honored guest.

In order to present the true background and animating spirit of our Association, may I ask you to look back over 1900 years to a recorded incident when our Lord was the guest where Mary and Martha were daughters of the house. Martha was cumbered about much serving while Mary sat with the guests. Martha protested to the Master that Mary should help her, but the rebuke recoiled on her own head. This historical incident gave rise to a remarkable legend which Kipling has dealt with in his matchless way. And speaking of Martha, Kipling says:

> And because she complained to the Master once
> And because she was rude to the Lord, her guest
> Her sons must wait upon Mary's sons
> World without end—reprieve or rest.

The dictum may seem harsh, so harsh that it constitutes an irresistible challenge to all who are called to serve their fellowmen and to serve them to such good purpose as this Association has done, that our advice and counsel is sought and followed all over this continent and other parts of the world:

Dr. Cody, it is my privilege to hand over to you this convocation of men worthy to be called the sons of Martha—the American Railway Engineering Association.

(The audience rose and applauded.)

Together in Defense of Transportation

By Dr. H. J. Cody, M. A., D. D., LL. D.
President, University of Toronto, Toronto, Ont.

About 20 years ago it was my privilege to address this Association, in the days when Mr. William McNab of the old Grand Trunk was the president, and we then came from Canada to present greetings to this formidable and active body of achievement.

And now, after this lapse of time, it is my privilege to accompany my friend, Mr. Bond, to bring greetings from Canada, to this magnificent group, and to bid you Godspeed and to remind ourselves that we are no longer merely neighbors, living side by side, that we are no longer merely friends who cherish each other in our hearts, but that we are comrades and allies in a great cause, the greatest cause for which men could shed their blood.

So I address you this noon, bringing greetings from Canada, as your ally in this common cause.

It is a great privilege to address the brains that operate the great transportation systems of this continent. Although you have rivals by land and in the air, it is impossible to imagine that the day will come when railway transportation will cease to exist.

What Is Engineering?

Engineers have always walked side by side with those who have developed civilization. Indeed, engineering is a handmaid of civilization.

What is engineering? Some of you may remember the definition found in the Engineering Building in New York, presented to the profession by Mr. Carnegie: "The art of organizing and directing men, and of controlling the forces and materials of nature for the benefit of the human race." May I repeat it: "The art of organizing and directing men"—no small part of an engineer's task is the task of getting on with men—"of inspiring men"—leading men, of making men trust him so they will do more than they are asked to do. But it is more than getting on with men, it is the art of controlling the forces and materials of nature in the interest of human welfare.

We are very apt to forget that we have made greater progress in mastering the forces and materials of nature than we have made in mastering ourselves. I have been interested in reading the annual addresses of the presidents of the British Association for the Advancement of Science in recent years. Each one of them, in turn, has emphasized the fact that, while we have controlled the forces of nature, and are able to guide them, we cannot yet fully control ourselves. Hence the tragedy of this present hour.

But to come back to our definition of engineering. Engineering has a relation to men and women. It also has a relation to the forces and materials of nature, and by controlling men and women, and by utilizing the forces and materials of nature for the benefit of the human race, it has become one of the chief agents in the advance of civilization.

Now, I want to speak to you for a few moments after luncheon on the subject, "Together in the defense of civilization." Here are, naturally, three outstanding words—civilization, defense and together.

War in the Background and Foreground

The war is the background and the foreground, at the moment, of all we think and say and do. Your various papers presented by the different committees and by authorities from Washington deal in every case, sooner or later, with the problems that the war has presented to us for solution.

The war is as wide as the world. Every one of the seven seas is today subject to warlike attack. It is a war of ideals as well. I suppose if you test it on its idealistic side, there never has been a struggle in which the issues were more clearly defined. We all know what we are fighting against, and, if we know what we are fighting against, we must, in a measure, know what we are fighting for.

It is a war not only of ideals but of applied science. That side in the grim struggle which masters most thoroughly the secrets of nature and applies them to immediate problems, is the side that will win. We are doing all this in what we call the interest of civilization.

Now, first a word about civilization. What is it? Civilization is the art of making civil people—people of a certain kind. It is not tested simply by improved methods of intercommunication. It is not tested by mechanical devices. But civilization is tested by the extent to which men and women and children thrown into close relations with one another are able, by their various gifts, to enrich and to enlarge one another's personalities. Civilization means, may I repeat, the making of civil persons, the enriching of human personalities. In that sense of civilization, we may analyze the concept.

The Sources of Civilization

Whence come the various elements that make up our western and Christian civilization? One element came from ancient Greece. This element was the love of truth, the search for accuracy, appreciation of beauty and, above all, the quest for freedom, the scientific spirit, the spirit that searches for freedom, that loves freedom, that holds freedom in trust for others. That is the Greek contribution to what we mean by civilization.

Ancient Rome, standing in marked contrast to the poor, pale Rome of today under Mr. Mussolini, did make a worthy contribution to western civilization. What was that contribution? It was the contribution of law, the reign of law, ordered freedom, not freedom that degenerates into license—the sacredness of contract; law, order, organization, the sacredness of contractual relations are part of the inheritance that has come to us from ancient Rome.

Then there is another source, perhaps the supreme source of what is noblest in western civilization, and that is the contribution which the Jewish-Christian religion has made to mankind, the contribution that regards every individual as of supreme value because he is God's creature, because in the sight of God he is of inestimable value. Apart from that Christian or Jewish faith, I doubt if any democracy could be permanent and noble. From that religious source there has come to us the practice of kindliness, of tolerance, of helpfulness, because each individual human being has a value in the sight of God and, therefore, in the sight of man.

You might add, if you choose, a few other contributions down the ages. We know something of an age of chivalry. The age of chivalry contributed the element of tolerance and generosity and help readily ministered to the needy.

If you come down still further to the age of the Renaissance and the Reformation, you will find a restatement of the value of the individual and the right of the individual to think for himself and to stimulate his powers of intelligence and of inquiry.

Come still further down and you will find that France at her best, not that vitiated France that you, Mr. Chairman, so well described as the "Vichyated" France of today, but the great France, made a contribution to western civilization of intellectual integration, of the value of logic, of appreciation of esthetics.

Then there is the contribution that was made by Great Britain, from the little islands northwest of Europe. That contribution may be summed up under the heads of decency and duty. There are two great contributions that those little islands have made —the idea of duty and the idea of decency, of being a gentleman. There are some things you ought to do. It is right that you should do them. And there are some things that no decent man would ever dream of doing.

Those are valuable contributions to make to the sum total of western civilization.

Ladies and gentlemen, if you add together all those elements you have as a resultant what we know as western civilization.

The other day, in the City of New York, Lord Halifax put these ideals of western civilization in another fashion. He said there were four great principles which are essential to our very conception of a worthy life. There is the religious principle that regards every man as the creation of God and precious in the sight of God. There is the moral principle that lays emphasis on the sacredness of individual personality. There is the social principle that expresses itself in individual freedom; this on the political side, is illustrated by the respect we pay to the rule of law, to the administration of justice and, on the economic side, by the desire to provide for even the humblest among us some sense of economic security. And there is a fourth principle—the domestic principle—the sacredness of the family, which is only the extension of the sacredness of the individual.

From those two analyses that I have suggested, we have some concept of what civilization is. What are the fruits of this civilization? Freedom, perhaps in the first place, the rule of equal law, the sacredness of treaties and contracts, the development of tolerance and kindliness, the belief that the state exists to serve the people and not to dominate over the people; the recognition that even the humblest have rights.

That is the civilization which today we are called on to defend.

The Assault Upon Civilization

Now, my second point is that this civilization is being subjected to the gravest attack we have ever known in the long history of mankind. Germany and Italy and now Japan have launched their assault upon us, upon our western and Christian or religious civilization. What are their concepts of life? You can analyze these also—glorification of war, particularly aggressive war, the breaking of a pledge or a treaty, if you think it will help the interest of the nation; the recognition of a kind of Messiahship or dictatorship or leadership; an anti-Christian morality and religion; the degradation of history and law and science, so that they become mere agents of the state. Law in Germany today is not based on any fundamental principle but only on what the judge believes the Fuehrer would wish in the interest of the state.

Verily, Mr. Neville Chamberlain, former prime minister of Britain, was right when he said that we were "fighting evil things." What is the swastika? It is a crooked cross. All the highest and noblest contents of our consciousness today are represented by the cross. The swastika is the perverted cross, and every one of these loftiest and noblest of concepts has been degraded and repudiated.

Thirdly, we are called upon to defend this civilization. And who are in it? Who are the defenders? Who are the high crusaders? You remember in days of old, the sacred places in Palestine were defended by knights from western Europe. Today we

are trying again to defend not sacred places but sacred conceptions, and sacred factors from the foulest and cruelest of assaults. Who are the defenders?

I name China first because China began this struggle years ago. Let us pay our deepest tribute of honor and respect to that ancient and cultivated land of China. The other day the leader of China, Chiang Kai-shek, came to India and visited the leaders of the Congress party to put before them the extremity of the present peril. In effect, he said, if I may paraphrase his words: "Our two peoples must do our utmost together to maintain the freedom of the world." Then he went on to point out that, if freedom is lost anywhere, in measure it is lost everywhere. Chiang Kai-shek is standing as one of the leaders of freedom and of democracy in the continent of Asia.

Then came Great Britain and the British empire—all the British empire, alas, except the Irish Free State. One of your own journalists wrote the other day, rather an amusing but biting paragraph that is worthy of repetition: "Ireland is neutral, is it? De Valera said Ireland is neutral but she ought to be prepared for war, because war may sneak in like a thief in the night. Well," says the journalist, "that's a fine thing. The whole world is fighting the thief in the night and Mr. De Valera says that Ireland is just sitting and waiting for it. That doesn't sound like Ireland to me. Here is the best war anybody has had the privilege of fighting, and Ireland isn't in it. That sounds crazy to me." Then he concludes, "and think of it, the first American hero of the war, the American airman who gave his life in the effort successfully to destroy the battleship Haruna was a man called 'Kelly' and that sounds Irish." (Laughter and applause)

Then in came Russia. We do not need to adopt Russia's internal organization. We may well allow Russia to determine that for herself, but I think we might just as well follow Mr. Churchill and say, "Frankly, thank you", that the grimmest and most formidable and most ruthless of all our enemies is being checked today by Russian armies. (Applause)

Then at last came the traitor who beyond the wont and custom of decent nations, struck a deadly blow in Pearl Harbor. So the United States joins with the others in defending this priceless gift of a humane, decent and Christian civilization.

The Defense of Civilization

When I say "defense" I do not use it in the strict sense of the term, because all those who are most entitled to speak with authority remind us that today the best defense is offense, and that we must try to strike our hardest blows where they will do most damage to the enemy. So, we cannot spread our forces all over the land, but we must strike where the blow will be most deadly.

Lastly, I want to say a word about that word "together"—together in defense of, in vindication of, to win the victory for, humane and decent civilization.

Why are we in this fight? We don't love war. We have done everything within our power to avoid it, but here we are in it. We couldn't avoid it. The enemy has been preparing for years, and we are now in a life and death struggle. Men and women, for God's sake, don't minimize the seriousness and the peril of the situation. It is not an ignoble motive to fight for your own survival. We believe that God has set us here in this world to render a certain service to the world, and we are being hindered. We are fighting for fundamental issues. To be sure, it is in our own interest that we should maintain our freedom. It is in our own interest that we should trade freely with the rest of the world. It is in our own interest that we should live our own peaceful way of life. But deep down underneath all that, there are fundamental issues before which no man can remain neutral. It is really a fight between good and evil.

Many of you have read Bunyan's "Pilgrim's Progress", and you may remember the scene when Christian, in the valley of humiliation, stumbling along, conscious of his own weakness, and yet with his face set to the light meets Apollyon, the destroyer, the very embodiment of evil, and the fight is for life or death. This is a parable of the present struggle.

Indeed, I may go farther and say that it is a fight between life and death, a fight between all that makes life worth living and all that is most deadly in conception and in practice.

The British empire and the United States are really the nucleus in this great effort for freedom. I beg of you, don't let fifth columnists, don't let propagandists stir up ancient prejudices and misunderstandings and animosities between Britain and this continent. The vital thing today is that we stand together. If we don't stand together, if one of us goes down, the other goes down, and the whole world of freedom is lost.

An American has the same feelings toward life that a member of the British empire has. There are special ties that exist between us, which exist between no two other nations. Those ties are based on deep and fundamental agreements in our sense of the basic values of life, and the world of the future will be determined by our unity. Others will join, to be sure. Lovers of freedom the whole world over will join. But we shall be the nucleus. Is there any finer, visible representation today of this unity than the fact that your General MacArthur has been invited to be the commander-in-chief of the forces in Australia? (Applause)

One more word and I have done. Don't underestimate the power of the enemy. It will take all our effort to win. How long will it last? That depends on how hard we work and how soon we begin to work hard.

There is a story told about a veteran mountaineer, who with a young man, climbed a peak of the Pyrenees. Night fell before they reached the top. They had to camp all night. In the early morning a terrible thunderstorm broke out—wind, thunder, lightning combined. The young man said, "This is the end of the world."

And the veteran said, "No, it is not the end of the world; it is only the beginning of a new day."

God grant that out of the present chaos there may come the new day.

(The audience arose and applauded.)

Vice-President Clarke: The American Railway Engineering Association has been in session for a day and one-half. The sole purpose has been that we might learn more about the job that is ahead of us and how to do it better. We have another day and one-half of equally hard work ahead.

In this all too brief interlude of sociability and fellowship, a phrase has occurred to me which I hasten to assure you is not original, but I think it is appropriate, and that is "The pause that refreshes." It has refreshed us physically, and it has challenged and stimulated us mentally.

I have always been proud, as I am sure has every other man who can say that he is an engineer, to claim that title, and, Dr. Cody, since listening to the splendid tribute which you have paid to engineers, I will say in the future, with more pride than in the past, that I am an engineer.

I have never, as yet, been able to visit that great Dominion which lies to the north of us, but I have had the privilege of knowing intimately a few splendid men who have come from that great country, and I cherish those friendships deeply. I assume that it is that slight spirit of egotism which may be present in all of us, that causes us to

believe that the greatest tribute and the highest compliment we can pay to anyone, be it an individual, a group, or a nation, is to say they are our kind of people. President Bond and Dr. Cody, I assure you that we of the United States are saying that of you from Canada. I hope you can say it as sincerely and as earnestly of us. That we should feel that way is not strange, for the two countries, the Dominion of Canada and the United States, occupy the greater portion of the North American continent, and they occupy it with only an imaginary line between them. In saying that, I am not forgetting the strategic importance of the country which lies south of the Rio Grande.

Dr. Cody, you have emphasized that in this struggle we must stand together, and, certainly, that cannot be emphasized too strongly. But, if we are to be together, we must know and understand each other. I think, perhaps, I can say what I am going to say now a little better than some others might, for I was born in the British Isles. I am not sure that we understand the English people, and I am no more sure that they understand us. But Dr. Cody has well emphasized the tragedy it would be if we did not work together. I think there is a splendid opportunity and chance that we will. It is inconceivable to think we would do anything else.

I believe that such associations as this, the American Railway Engineering Association, which numbers among its membership many honored members from Canada; and addresses such as we have just heard, from outstanding men from Canada, help us understand each other better.

It was suggested quite recently that perhaps Canada might be the link which would bring about a better understanding between the two great branches of the English speaking people, and this occasion has contributed its portion to that understanding.

Dr. Cody, on behalf of the American Railway Engineering Association and all the friends assembled, I extend to you our sincere appreciation and our gratitude for the challenging, the inspiring, and the stimulating message which you have brought to us. (Applause)

President Bond: Ladies and Gentlemen: It is my very sad duty to let 733 people know that this delightful interlude must now come to a close. But we want to thank you most sincerely for the attendance, and we will wish you all good-bye until the next President—we won't say who he is; we don't know yet (laughter) but I think I can see his face getting red (laughter)—calls you together about this time next year, which we all have reason to believe and hope will be the beginning of happier days to come. (Applause)

(The meeting recessed at 2:25 o'clock.)

Railway Maintenance Materials and Priorities

An Address Presented Before the Session on Tuesday Morning, March 17, 1942

By Andrew Stevenson

Chief of Transportation Equipment Branch, War Production Board
Washington, D. C.

It has been a pleasure to accept the invitation of the Association to meet with you today to discuss what the railroads may expect in the way of materials for maintenance, for I am sure that we all appreciate that it is appropriate now to review the situation. One cannot sit very long in the Transportation Branch listening to the difficulties experienced in receiving materials without being aware that in this particular field, as indeed in all others, the situation has become increasingly critical.

The Priorities System

I should like primarily this morning to discuss the way in which materials are made available—namely through the priorities system. This seems especially pertinent in view of the fact that up to the present there has been no specific procedure in effect covering provision for maintenance materials, other than the over-all A-10 rating in Order P–100, applicable to all industries.

Preference Rating Order P–88, providing the mechanics for priority assistance for railroad maintenance, has just now been signed.

All of you are to some degree familiar with the priorities system as set up under the Office of Production Management and now functioning as part of the mechanism for control of materials operated by the War Production Board. In your morning newspaper you read of a new order that will control the use of some metal, you note that more material delivery assistance is given to a rapidly expanding industry, and you obtain the details of a restriction placed on the manufacture of some very useful object, perhaps a washing machine, that does not have a direct bearing on the military effort. You have made your field inspections to determine what repairs and expansions of facilities are needed during the current year; your management has approved the program, and the necessary money is available, but the materials required for your plans arrive very slowly, or not at all. The priorities system, which interested, amused or exasperated you, as you read your newspapers, has now landed on your own right of way, and the consequent problems will become a very important part of your work life. It would be a beautiful simplification to just blame it all on some people in Washington, and justify any transportation failure by saying that the materials allowed are not sufficient for the job; but it is now your business to deliver the goods in greater volume and more efficiently than ever before. This you have done during the past year, and I am confident you will do as well this year and next if necessary, although I do not believe there will be an appreciable easing of the material situation.

How to Get Materials

You know your work is essential, and you know that all the essential industrial functions must be maintained, even expanded in many instances, so you may properly ask how you may get the materials necessary for the operation of your railroads.

About a year ago, shortages began developing in the essential materials as a result of the impact of the defense program. Some of the shortages were really delays in deliveries, some were forecast rather than actual, but some were genuine. These developments brought about the definite realization that it was absolutely necessary to conserve

all the critical materials, direct their flow and govern their use. To this end the Office of Production Management initiated and operated the priorities system, the same work now being under the control of the War Production Board.

At first, major emphasis was on dates of material deliveries, and, although this emphasis has remained of prime importance, the time has now arrived when we must recognize that many essential demands will be met with greatly deferred deliveries. The procedure that has been followed has been basically simple, and has consisted of the practice of applying a so-called preference rating to all deliveries of critical materials, the term "critical" being applied to all materials of which the everyday supply is insufficient to meet demands. The preference ratings that have been set up are divided into two categories, the A or defense ratings, and the B or civilian ratings; the former start with the highest rating of AA and step down by 18 intervals to A–10; the latter start with the highest civilian rating of B–1, immediately below A–10, and diminish by 7 intervals to the B–8 rating.

Then the Squeeze Came

When originally set up, the A preference ratings were sufficient to cover all military and even debatable essential civilian demands, with large quantities of materials remaining for orders bearing the B ratings—even plenty left for automobiles and pin ball machines without any rating. This condition lasted into the fall of 1941, but, before cold weather arrived, the "squeeze" was on for many of the critical materials. Items such as pig iron, aluminum, magnesium and many chemicals, were scarce and have grown scarcer to this day. As originated, preference ratings mainly governed deliveries; they still govern deliveries, but in the case of numerous items, they also determine whether or not a material may be obtained at all. There are some materials that are in such great demand and such relatively small supplies exist, that no deliveries are made on preference ratings lower than A–10; some materials cannot be delivered on ratings less than A–3, and there is an ever-increasing list of items that are unobtainable on preference ratings lower than A–1–j.

As indicated previously, preference ratings are assigned on each delivery of critical materials, but each of these preference ratings is not individually assigned. The instruments used to make the priorities system function are a number of documents issued as orders by the Office of Production Management and the War Production Board. These separate orders pertain to definitely described materials and cover the uses of these materials by definitely described persons.

Four Types of Orders

These orders are of four general types described as follows:

"M" Orders.—These orders may be more specifically described as the material orders, because certain basic and scarce raw materials have regulations prescribed governing their distribution and uses. It is an "M" order, No. 21, that controls the distribution of steel; Order No. M–9 governs the flow and use of copper and copper scrap; and Order No. M–55 regulates the distribution of sugar. The "M" orders are the most important of all the material control orders because they contain the rules governing the uses of the raw materials. It may be contended that materials might be readily controlled at any point in their processing from their natural state to the finished form in which they are received for general use, but the most economic control is exercised on the raw materials as used in industry. With this type of regulation, there is no waste of plant facilities and labor incident to subsequent needless fabrication.

"P" Orders.—These are preference rating orders that assist manufacturers and other industries to obtain materials or parts required for plant maintenance and for production to meet military and essential civilian requirements. These usually contain a blanket preference rating that may be applied, by a company, group of companies, or all engaged in a certain industry, to the delivery of materials for certain prescribed uses. There are about seventy-five of these orders, and they cover practically all industry for maintenance purposes, and a large part of industry for production purposes. Railroad freight cars are built and repaired by means of the priority assistance extended in Order No. P–8; locomotives are built under Order No. P–20 and maintained under Order No. P–21.

Railroad construction jobs are included under Order No. P–19–a, which is generally called the Project Rating Order. It is used to obtain priority assistance upon the delivery of materials for construction projects, other than roads and defense housing, within the continental limits of the United States. It is an essential instrument available to each chief engineer. Its application is very simple, and as a variable preference rating can be obtained, it is possible to secure a rating in accordance with the urgency of the need for the expanded facility.

"L" Orders.—These are limitation orders, setting limits on production or distribution of certain items, especially consumers' durable goods. When production is limited, the purpose is to conserve the materials that enter into the production, and when distribution is restricted, the objective is to direct the flow of the finished product to the required military and essential civilian uses. Some of these orders have both limiting and expansive features, in that they limit materials to be used in the manufacture of complete products, but increase the material allowance for production of maintenance and repair parts. As examples: Order No. L–27 limits the production of vending machines; L–53 restricts the distribution of crawler or track-type tractors. I am sure you will agree that that is very important as far as maintenance is concerned. L–26 limits materials that may be used in new farm machinery but increases material allowance for repair parts. A certain past period, or periods, is taken as a basis for comparison and when production is controlled, the control is on units of production or on material consumption. In simple terms, all of the "L" orders spell scarcity, and are indicative of the present need to conserve materials for the essentials, and direct the flow of production where it will do the most good. It was by "L" orders that passenger automobile manufacture was stopped and electric power consumption was restricted in the Southeast last fall. If we lose our neckties and the cuffs off our trousers, it probably will be due to a little "L" order in the woodpile.

"E" Orders.—The "E" stands for equipment and the "E" orders regulate the distribution of equipment, including machine and cutting tools. So far there are but four orders of this class. These orders have been issued since the first of this year so they are quite young in the priorities system, but due to the importance of manufacturers' equipment in our present effort, these orders are of vital significance.

Specific Preference Ratings

In addition to these blanket preferences, the specific Form PD–1A is a very important part of the present setup. PD–1A is a form that is used in submitting a request for priority assistance to apply on the delivery of certain definite items of material or equipment, for which delivery the applicant does not have a preference rating assigned by preference rating order, or if he has the rating, the request may be made for a higher rating. This form may be submitted by any individual or company, domestic or foreign, and the items listed may be for practically any use, except that there are

restrictions on materials for new construction. The restrictions are indicated by the previous statement that new construction should be handled under the terms and provisions of the Project Rating Preference Order No. P–19a. PD–1A is the "filler" that completes the pattern of "P" orders, presenting a means of obtaining priority assistance for delivery of those materials and equipment not included in the general orders, and allowing those individuals and companies, whose activities are not covered by one of the general orders, to make their applications for preference ratings. It is under these PD–1A orders, for instance, that foreign railroads make application for material assistance.

Operating supplies and materials for railroad maintenance and repairs, other than those for freight car and locomotive maintenance, are obtained in most instances by means of the A–10 preference rating assigned in Preference Rating Order No. P–100, the almost all inclusive industry maintenance, repair and operating supply order. If higher than A–10 rating is required for these materials, an individual Form PD–1A application for preference rating is submitted by the railroad. New shop equipment, maintenance of way machines, motor cars, welding generators, floodlights, fences, passenger car equipment, transformers, electric cable, and so on, are also covered by the Form PD–1A applications.

This description of the priorities picture surrounding the railroads indicates that some of the railroad transportation functions are obtaining an inferior treatment in comparison with others. Freight cars have A–3 priority available, but the passenger car maintenance must depend largely on the A–10 rating contained in Order No. P–100. Despite the vital part played by the maintenance of way department, track and structure repairs are also in the A–10 rating category. From the standpoint of the War Production Board, the picture also has not been satisfactory. Blanket preference ratings, like the A–3 assignment in Order No. P–8, usually have definite inventory controls, and none of the railroad preference orders have such controls. The railroads' needs and the War Production Board inventory control requirements have necessitated the preparation of another railroad order.

The War Production Board is accordingly now issuing an over-all railroad maintenance, repair and operating supplies preference rating order designated as No. P–88. This order is not in use at this immediate time because of the mechanical details incidental to forwarding and obtaining acceptances from the railroads, but it is issued, will shortly be available, and all of the railroads should be operating under its benefits and requirements within a few weeks. Order No. P–88 contains preference rating assignments that may be applied to all the maintenance, repair and operating supplies required by the railroad operating thereunder. There are four separate assignments of preference ratings listed as follows:

1. A–1–a preference rating for delivery of materials needed for emergency repairs.
2. An assignment of preference rating to deliveries of raw materials by calendar quarters, this assignment to be determined by the Division of Industry Operations of the War Production Board after consideration of requirements as submitted by the railroad on Form PD–351, in conjunction with a statement of inventory condition presented on a complementary Form PD–352. (It is under this type of form that rail is covered.)
3. A–3 preference rating for delivery of fabricated materials essential for track, structure, signal, communication system, train and locomotive maintenance, repair and operation, including perishable tools.
4. A–8 preference rating for delivery of other maintenance, repair and operating supplies.

The inventory control is obtained by means of quarterly forms, and the use of all the preference rating assignments is predicated on compliance with this requirement.

Order No. P–8 and P–21 have been extended to April 30, 1942, to allow for the interim between the issuance of Order No. P–88 and its acceptance by all the railroads. The Orders No. P–8 and 21 will not be further extended; when a railroad accepts Order No. P–88 it is not allowed to use preference ratings assigned by Orders No. P–8, 21 and 100. Builders of freight cars and locomotives are being directed to begin operation under the Production Requirements Plan, but to take care of the latter during the transition period, Orders No. P–8 and P–20 have also been extended to April 30, 1942. Special requests for preference ratings and requests for priority assistance to apply on delivery of new equipment will continue to be made on Form PD–1A. New construction will still be handled by means of Project Preference Rating Order No. P–19–a. A railroad that wishes to build cars or locomotives must do so under the Production Requirement Plan, in a manner similar to that of the private builders.

Will Not Assure Materials

A description of the manner in which you apply for a preference rating, so that you may order materials, is not complete, however, without some comment on whether these orders will be filled. These preferences either under a blanket order or individual rating do not assure the materials. They only permit the recipient to secure them if the supply of the materials has not been exhausted by purchases on higher ratings. But to say that one does not get materials because his rating is not high enough is not a proper statement. He does not get materials because there is not enough to go around, and in the decision as to the relative importance from the war effort of which purchaser is to have his order filled, he is placed down in the list. The preference rating system is only the mechanics for the expression of this relative importance and the filling of orders accordingly.

Obviously, the only way in which any purchase of material would be assured is through a direct "earmarking", or segregation, or allocation of the material. To do this, however, requires, first, a determination of the amount of material needed, and, second, a determination that up to such amount this particular need shall transcend all others. These determinations are primary; the getting of the material to the proper person becomes only a matter of mechanics and can be handled in several ways. P–88, with its individual report forms and individual ratings, is one way. The combination of P–95, the farm preference order and L–26, the farm limitation order, is another. P–90, the Production Requirements Plan for manufacturers, is a method, and so is P–20, with its control and scheduling of locomotives.

In order to make the determinations which must precede this sort of assistance seeking to assure materials rather than merely condone their purchase if possible, the Supply Priorities and Allocations Board, and now the War Production Board has presented to it for approval "programs" calling for definite amounts of specified material during designated periods. Programs for the railroads for the first quarter 1942 are in effect for both repair and construction of equipment and for maintenance of way and structures. The effectuation of the program for equipment is handled by special directives supplementing the blanket orders. The effectuation of the program for maintenance of way is handled only as to rail, through special directives. The new P–88 will permit applicability to all items.

You are aware of the extent of the first quarter programs. They called for 1,787,000 tons of material for repair and construction of equipment, providing for 36,000 new freight cars and continued work on 926 locomotives, and 900,000 tons of material for

maintenance of way and structures. Of the latter amount, 538,000 tons originally were specified for rail, subsequently revised to 350,000 tons this quarter.

Recommendations for material for the balance of the year are being made to the Board by the Director of Defense Transportation and shortly will come up for consideration and determination. Maintenance material for each railroad will then be alloted through P–88 in keeping with the over-all commitment contained in the Board's determination.

It cannot be too strongly emphasized that the assurance of materials provided through these programs carries with it a responsibility that every pound be utilized to the fullest. The ever increasing demand for war goods, which is the nation's primary concern, will involve the major portion if not all of certain kinds of these critical materials. Their use in railroad maintenance where adequate substitution or elimination is possible, of course, cannot be countenanced. In this, much has been done by the railroads in finding substitutions or in changing specifications which will save metals completely. You are aware of the increasing number of these actions. But, I urge you to exert extraordinary vigilance in the continued pursuit of these savings, of putting them promptly into practice, and of preventing undue accumulation of inventory.

I believe that you are appreciating the situation. This is evidenced by decreasing number of applications for materials for items like new passenger station facilities, for new sanding and coaling stations where the old are yet usable or comparable facilities exist on adjacent roads in the same terminals, for the replacement of yet serviceable trestles, for the undertaking of grade crossing eliminations—why these should be essayed at this time I do not know.

Further suggestions and conservation projects from you are yet in order, however, and I hope that these gatherings in Chicago this week will be of vital moment in this regard. I earnestly commend for your consideration such subjects as: Elimination of steel and cast iron pipe and substitution of locally available tile, unreinforced concrete and wood boxes; the use of lighter track accessories, particularly in turnouts and crossovers; the return to the use of 24-in. rail joints; the use of open-hearth steel in track and structural designs in place of alloys; the elimination of rubber.

I think it incumbent to point out the need for conservation, at least in consideration of your plans for additional work equipment.

At the present time, Mr. Chairman, in addition to my duties in the Transportation Branch, I also have those as the acting head of the Construction Equipment Branch. We started off with automotive transportation and farm equipment, with construction equipment thrown in. Gradually I think we are getting down where the work is such that it can be handled most expeditiously and given the immediate attention which all of you deserve, at least when you come in with your application.

In construction equipment, I must point out there will be little output which will be available for the railroads. I feel that we must review the maximum utilization of our existing work equipment, such as bulldozers, compressors, generators, cranes, draglines, tie tampers, and bridge and building equipment. Perhaps we can double the use of the existing equipment by longer hours or by putting on double crews or large enough gangs to keep this equipment busy.

The question of rail I know has been close to your hearts, as it is also to mine. In our December 12 meeting we took up with the Railroad Advisory Committee the matter of estimates for 1942. Those were reviewed and a revised estimate presented to the branch in the early part of January, which was in excess of that which had previously been arrived at in the fall of 1941, and this in face of the fact that war had

already broken out and that the demand for steel, owing to the increased war effort, was then known to be tremendous.

Accordingly, in the industry meeting of January 19, we presented, to the Advisory Committee a program for the first quarter which called at that time for the maximum amount of rail which we thought could be rolled for the domestic railroads, which is placed at a total of 538,000 tons.

Subsequently it developed that there were additional demands on the rail mills of such special character, that they could not be taken off. Indeed, by the middle of February, it appeared that in March of this year little or no rail whatever would be rolled for the domestic railroad. However, that situation was very earnestly and vigorously reviewed by the Transportation Branch, and 150,000 tons are now scheduled on the mills for the month of March. This arrangement for new rail is tied up with a commitment in which the railroads very heartily and cordially joined, that we would release relay rail for the use of the armed forces.

The difficulty at the present time is that these new defense plants and new camps are coming in so early that relay rail is more or less at a premium. Unless we are able to deliver increasing quantities of relay rail, we are going to be faced again with the alternative suggested by the armed services, and very properly so, of placing orders for new rail. This I think neither of us desires to have happen. The army has cooperated very cordially in the use of relayer rail, and at the present time all of the various bidders for relay rail have been centralized in one place, namely, the Transportation Branch, and it is up to our branch to deliver an amount of relay rail during the ensuing months which will meet the requirements of the Army and Navy and Lend-Lease Administration.

We must have the rail, gentlemen, and I urge you, accordingly, to lay the new rail you receive, as promptly as possible, even though it may result in some inefficient use of labor. But it is only through the release of this relay rail, and that very promptly, that we do not get into terrifically competing demands for new rail.

Thank you for this opportunity of being with you here today, because I feel that out of these sessions have come, and I know will continue to come, practical ideas and helps which will go far in freeing more and more material and facilities for use in constructing more and more tanks, planes, guns and ships. For only in the production of these war goods—production now—will the war be won. (Applause)

C. E. Smith (New York, New Haven & Hartford): I ask the privilege of the floor to express my appreciation and, I am sure, the appreciation of all those present here today, as well as the appreciation of the railroad industry for the honor Mr. Stevenson has conferred on us by coming here from Washington and presenting this very comprehensive and lucid exposition of the railroad material problem.

I am a civil engineer who after 30 years of railway engineering was transferred, up or down, as you please, into purchasing work 12 years ago. I believe I understand the problems of the maintenance of way engineer and of the purchasing department. For about a year I have been in Washington every week regularly contacting Mr. Budd, Mr. Pelley, Mr. Buford, Mr. Stevenson since he has been chief of the Transportation Branch, Colonel Young when he was in Mr. Eastman's office and the Purchases and Stores Division of the AAR. I have a pretty fair understanding of the material problem in Washington as well as at home.

There could be no more appropriate audience anywhere to have listened to Mr. Stevenson's talk than this audience here today. I believe, and I carry the impression

pretty distinctly, that the maintenance of way engineers have been rather thoroughly sheltered, if you please, by the purchasing departments.

I have rather felt that, when the engineering departments submitted their requisitions to the purchasing departments, they thought their work was done, their responsibilities had been passed on, and, to the extent that they got tough with the purchasing departments, the latter should be tough with Washington and get them what they wanted. That is not the way to get materials.

It is necessary for all of us to distinguish between the word "wants" and the word "needs." Washington has demonstrated rather positively during the last year, since the material emergency arose, that railroads can get all they *need*. If you don't believe that, look at our inventories. We have conducted more transportation, more maintenance of equipment, more maintenance of way, have used more operating supplies, more maintenance materials and more for construction, notwithstanding which our material inventories today, with notable exceptions such as rail, are higher and in a more satisfactory condition than they were a year ago, and all that has been done under Preference Rating P–100, with A–10 priority rating, and A–3 on cars and locomotives.

Now we are about to step into a preference rating of a much higher class, which is very largely due to the personal work and effort of the speaker to whom I am now responding. He has worked hard for several months to get this new preference rating P–88 through. However, that does not mean that we are going to get more materials because we are going to have a higher rating. It means to me that we are going to get quicker deliveries, because the new rating will lift many of our deliveries out of the A–10 class, which is applicable to hundreds of thousands of industries. Raising our ratings from A–10 up to A–8 and A–3 and A–1–a in emergencies is going to insure quicker deliveries, and that is going to enable us to rely less on inventory. We should now look carefully at our inventories and begin drawing on them to aid the war effort.

If you were Secretary Knox sitting on the War Production Board and the question were presented to you whether a rail mill should be used for shell billets for a fleet about to go into action or rail for the American railroads, what would your answer be? If you were General MacArthur in the Philippines and were asked whether a rail mill should be used to roll rails or shell billets for your army, what would your answer be? If you were Secretary of War Stimson on the War Production Board and you were told factories could turn out either crawler equipment for railroads or tanks for battle for an army about to go into battle, what would your answer be?

I know what all your answers would be, and that is why we are not going to get a lot of the equipment we would like to have. Therefore, it is going to be necessary for us all to distinguish clearly and positively between the words "wants" and "needs." If by inventory control we run low on certain items, this new A–1–a preference rating which Mr. Stevenson is now authorized by the War Production Board to extend in case of emergency will insure our getting such materials quickly. We have got to maintain our railroads with what we can get. We have to get away from the idea that we can get all the materials we would like to have, but I believe we will get all we need.

When we swing from our needs to the things which for years we have wanted, wanting them and not being able to get them because during the depression we didn't have the money to pay for them, wanting them now and being able to get them authorized by our managements because there is money to pay for them—it is going to take a lot of self-denial on the part of all of us not to say, "I want that. My railroad has money to pay for it. I can convince my management that it should let me buy it. I will dump this baby in the lap of the purchasing department and say 'Go get it.'" But we shouldn't proceed on those lines at all. Each of us should start at the source,

way down at the bottom, and, whether he thinks of something he wants and honestly, after examination of conscience, he determines he doesn't absolutely need, he should say, "If I get that by any hocus-pocus or force or misrepresentation, some soldier or some sailor doesn't get it"—our answer should be, "No, I won't ask for it."

Mr. Stevenson, let me repeat—I believe I express the sentiment of the whole railroad industry in thanking you for honoring us by such a comprehensive and lucid exposition of this subject. (Applause)

Be on the Alert

An Address Presented Before the Session on Tuesday Afternoon, March 17, 1942

By Joseph B. Eastman

Director of the Office of Defense Transportation
Washington, D. C.

Last summer I heard a man—I think it was Dr. Conant of Harvard—say that World War I was a war of chemical engineers, whereas the present World War is a war of mechanical engineers. I suppose that, like most epigrams, tells a part of the truth, but only a part, and certainly it is not a matter on which I can pass expert judgment. Even the man in the street (whom I am one for this purpose), however, knows that this is a war of machines of most intricate and highly specialized construction, and that it cannot be fought successfully without the continual help all along the line of the most expert engineers that can be found, whether they be civil, mechanical, chemical, automotive, aeronautical, or any other variety. It is also one of the great resources of our country that it suffers no shortage of engineers nor any deficiency in engineering genius.

No better proof can be found of this fact than in the field of transportation. I am afraid that we have been guilty of some tendency to boastfulness, and it has been a source of danger, because along with it has gone a tendency to underestimate the competency and strength of the peoples of some other parts of the world. But we are rapidly being cured of that fault in the hard school of experience, and it is not boasting but only the truth to say that our engineers have created the greatest system of railroads in the world, the greatest system of highways and automotive vehicles, the greatest system of pipe lines, and the greatest system of commercial air transportation. You railroad engineers have a history which may well give you cause for pride, but in this life there are few more unsafe things than to rest on laurels, and you know better than I the peril of any such relaxation with a horde of automotive and aeronautical engineers pressing on your heels.

The New Challenge

The supreme challenge, however, which you and all the other engineers of this country are now facing is a far more serious matter and comes from a very different quarter. Our wonderful engineering achievements have been in the realm of peace. Lulled by a baseless feeling of security, war and preparations for war have with us been a side issue. But they have been no side issue with those whom we have now found to be our virulent enemies—far from it! The consequence was that before we knew it, suddenly it became necessary to mobilize all of our engineering ability in a new, strange, but common cause in which peacetime differences are forgotten and all are working together for the war-time salvation of not only our country but the whole world.

Only the adjective "stupendous" can properly describe the undertaking on which our engineers are now engaged, and it is only a part of the gigantic undertaking of the entire nation. Most of us have not yet begun to grasp what it really means or all that it will involve in the way of toil, hardship, and suffering. Step by step and with constantly increasing acceleration our huge resources are being thrown into the combat and our peacetime industries are being converted to war purposes. It is idle to think that this can be done without deprivation of many things which are not essential but which we have come to regard as only a part of normal life, or that it can be done unless our people are ready and willing to work somewhere near as zealously, steadily, and devotedly as the enemy populations, and to sacrifice and suffer.

Transportation, of course, plays a peculiarly vital part in the war effort. It enters into modern production at every stage, from the time the raw materials leave the ground until the time that the finished product reaches its final destination. Troops and munitions would be useless without transportation, and so would the workers in our great new war production plants. No one who gives a moment's thought to the matter can possibly doubt that of all the indispensable parts of the war effort transportation is the most extensive and pervasive.

There Is Danger of Trouble Ahead

All this is so clear that it needs no demonstration. Yet there is danger of trouble ahead for our transportation service. Nor is it difficult to understand whence this danger comes. Disregarding the rubber shortage for the moment, we are undertaking to create, in a time incredibly short for such an undertaking, armaments which will surpass the great combined armaments of our enemies and also the huge flotillas which will be necessary to transport through seas full of peril both armaments and men to the theatres of action. Inevitably those in charge of these mighty production programs look for every possible means of carrying them through, and inevitably, also, their eyes fall upon the well-equipped manufacturing plants which supply the railroads and other branches of the transportation industry with equipment and other facilities, such as steel rails.

There is an idea, also, which it seems that some may entertain, that a shortage of transportation is something that the country can endure, like a shortage of sugar, without harm to the war effort. So far as the transportation of passengers is concerned, this may, within limits, be true, but I fear that it is not true when it comes to the transportation of freight.

The production of commodities which may be classed as luxuries or even as nonessentials is rapidly being discontinued in favor of war production. We are approaching a time when the freight traffic which our carriers will be called upon to move will be made up mostly of commodities which enter into the war effort in one way or another, and the balance will be commodities, like food and clothing, which are essential to the well-being of the population. Assuming that there will still be some small room for shrinkage in that civilian balance, which may be doubted, will it be possible to segregate the transportation of such commodities from the transportation of those which go to make up the war effort?

Certainly I question the feasibility of earmarking at origin the coal destined for steam and byproduct plants as between that which is to be used in war production and that which is to be used for civilian supplies; and the same may be said of ore, cement, and other raw materials. Nor do I believe it is possible to carmark at source our agricultural products as between those which are essential in one way or another to the war effort of ourselves and our allies and those which we might perhaps dispense with

if we all tightened up our belts. As for manufactured products, if any remain which are not essential to war production or to the well-being and morale of the people, manufacturers will be in a sorry plight, if they are allowed to produce such articles and then find that they cannot be moved to points of consumption.

Transportation Must Remain Fluid

Not only that, but the efficient conduct of transportation requires that the carriers maintain their service in a state of the utmost fluidity. This requires the best efforts of both carriers and shippers. The new records which the railroads set in 1941 were made possible by such efforts on the part of both. Once a shortage develops, these favorable conditions will at once be impaired. Shippers will become disturbed and panicky. They will order more cars than they need, in the hope that in this way they can forestall the effect of the shortage. The carriers will find it necessary to watch shipper demands closely. The attention of both will be diverted from the vital thing, which is to keep the cars in rapid circulation. If priorities and embargoes ensue, a large administrative organization will be necessary and it will be hard to avoid confusion worse confounded. No one who has ever experienced a general car shortage can look forward to another with anything but foreboding. Under such conditions, in my judgment, transportation will inevitably become less fluid, and there will be a slowing down and impairment of general efficiency which will be bound to react on the war effort.

It is a part of my duty in my present position to do everything that I can to see to it that the carriers receive the materials and equipment which are necessary to keep their properties in prime working order and to enable them to meet the steadily increasing traffic demands. Yet I warn you that there will certainly be no abundance of materials and equipment, and with such stocks as may be made available the carriers will be hard put to it to maintain the record of 100 percent service accomplishment which they have, to their eternal credit, thus far so splendidly maintained. It is upon this point that I wish particularly to address you, for the railroad engineers will have much to do with the outcome. If I do not confine myself, in my remarks, exactly to your field of duty, I know you will forgive me.

Of course the rubber shortage is the greatest threat to future transportation service, for if highway automotive vehicles should cease to be the important factor in transportation which they now are, a crushing load will fall upon the railroads. The problem there, as I see it, is to keep the present vehicles, insofar as they now perform essential transportation service, functioning until such time as the creative genius of the country can furnish new supplies of synthetic or other rubber to take the place of the supplies which have gone. This means the conservation of tires and vehicles in every possible way and the elimination of all wasteful operation. The possibilities, fortunately, bulk large. To some extent, particularly in the field of maintenance, it will be an engineering problem. This is not an appropriate audience for any extensive discussion of these matters, for I doubt whether it is your kind of engineering, and it is primarily a motor carrier subject. But I do remind you that most railroads nowadays, notwithstanding their expressions of continued hostility to the motor vehicle, use it, directly or indirectly, very extensively in their own operations and will find themselves in a very trying situation if they are deprived of such use. Conservation of tires and vehicles is, therefore, something which the railroads must perforce take to heart.

Turning to what is your more immediate concern, it is quite clear that you will not have all the rail and track material that you would like to have or even that you will actually need. It will, therefore, be necessary for you to use what you can get in the best possible way and with the demands of the war effort uppermost in your plans.

The problem will be to produce the greatest possible improvement of transportation facilities per unit of material used. Projects that may appeal to you as desirable from a long range point of view may have to be discarded in favor of temporary makeshifts which will contribute at once to the efficient handling of the war traffic. It will require constant vigilance, imagination, and foresight.

It will also be necessary, in order that materials may be made to go as far as possible and that equipment and other facilities may be constructed with the greatest conservation and economy of plant operation, to pay more attention to standardization and simplified practice. This was, as you know, one of my obsessions when I was Federal Coordinator of Transportation. Not much success attended my efforts at that time, and no doubt many of you disagreed with my views for reasons which you then believed to be sound. But what may be good practice in peacetime is not necessarily good practice in time of war. I submit that present conditions do not permit the luxury of all manner of special designs and specifications. This is true of cars and locomotives, and I am glad to say that the fact is being given practical recognition, to a very considerable extent, in the cars and locomotives which are now under construction. But it is also true of such things as joint bars, tie plates, spikes, frogs, switches, etc. Standards have been established which can be followed, and they must be followed for the good of the cause. It will also be necessary, in many instances, to use substitute materials, as, for example, malleable iron in place of cast steel, and much ingenuity will be required in that connection.

The Need for Research

Perhaps it is too much to hope, but I cannot help hoping, that out of all this will come an impetus to the establishment by the railroads, after the war is over, of a centralized department of scientific and engineering research. You will recall that as another of my hobbies in the days of the Coordinator, and you may also recall the support which I got for that idea from a committee of very distinguished men, including six railroad presidents and representatives of some of the most important industries of the country. I am confident that such a department can be of great value to the railroads, not only in the reasonable promotion of standardization and simplified practice, but also in the best development of new types of equipment and improved operating practices.

While our railroads are owned and operated by many separate and individual companies and keen competition runs rife among them, nevertheless they are also operated to a considerable extent as a system, and this is particularly true of freight cars, which circulate freely all over the country, and of the functioning of the Car Service Division of the Association of American Railroads. Perhaps this is a little out of your line, but I think it clear that for the duration this idea of unified system operation and cooperation must be emphasized, with less stress on the competitive side. There will be increasing need for sharing locomotives and passenger cars, as well as freight cars, and for the pooling of various facilities and resources. We must use to the maximum everything that is available for use, and there is no way in which this maximum use can be attained without resort to the principles of cooperation and coordination. As you know, the Department of Justice has recognized the need for cooperation, coordination, and joint action under present emergency conditions, and has pointed out the way in which, with the help of the Office of Defense Transportation, these desirable results can be accomplished. We shall endeavor to give that necessary help and direction.

A Call for Creative Imagination

Coming back to your own particular field, let me remind you of the extraordinary feats which engineers are performing in the military operations which are being conducted all over the world. Much of the success which our enemies have so far achieved has been bottomed on the creative imagination of engineers and their ability to solve, with marvelous versatility and rapidity, the problems which continually arise, not only in the construction, maintenance, and operation of the modern machines of war, but on the field of battle. The engineers of this country must, and I know that they will, match and surpass them in such performance. But what I want you to bear in mind and realize in every fibre of your consciousness is that the need for such creative imagination, versatility, and ability to deal quickly and successfully with sudden emergencies is not confined to the military operations at the front. It extends back of the line to every phase of industrial operation, and particularly to transportation.

The phrase "on the alert" applies to transportation in war time quite as much as to situations like Pearl Harbor. It is no time for old routines or ponderous deliberations or set ways of thought. Before we are through, occasions will continually arise which will call for all manner of improvising on the spot and the use of plans and devices unheard of before. One good thing that war does is to stimulate the creative mind to such activity, with results which often remain to benefit mankind after the emergency has passed. I call upon you railroad engineers to remember that you have as vital a part in the war effort as our soldiers and sailors and to be "on the alert." Your country must have, not good performance, but super performance. I am sure that you can hold up your end. (Applause)

E. M. Hastings (Richmond, Fredericksburg & Potomac): I am asking the privilege of the floor for a moment, a privilege which I personally desire, because I am a neighbor of Mr. Eastman, just across the river from him.

This afternoon marks a highlight in the history of the Association. Mr. Eastman has come to us out of a most busy life, especially for the purpose of addressing this body this afternoon, a man who is crowded with many duties and has been, for many years, a friend of the railroads throughout his career. And today, should we search the country over we could find no more able friend nor splendid ally than we have in Mr. Eastman.

Mr. Eastman, this American Railway Engineering Association deeply appreciates your coming to us and giving to us this afternoon the splendid address which you have brought; and I hope that this splendid body of men, representative of this fine engineering association, will take home with them and ponder deeply the things that you have said, particularly those which stress the need for simplification and for standardization. May Hastings again say to you men here, as he has said year after year before, that the Manual of Recommended Practice of the American Railway Engineering Association contains those needed things of simplication and of standardization; and it is worthy of your full adoption and application to your own railroad.

Mr. Eastman, we thank you deeply, gratefully, for your coming to us this afternoon and giving to us this splendid address which you have brought. Thank you, sir. (Applause)

REPORT OF THE SECRETARY

March 1, 1942.

To the Members:

Like all other institutions of democracy, the American Railway Engineering Association must face the future with a firm and steadfast resolution to do its part, come what may. If the record of the period covered by this report may be taken as an index of future performance, the Association is prepared to carry on. The term, "period," as used here designates the calendar year in the report on finances; the Association year (from the end of one convention to the close of the next) in dealing with committee work, publications, etc.; and the 12 months from March 1, 1941 to March 1, 1942, in the report on membership.

To sum up, the accounts of the Association for the year ending December 31, 1941, showed an excess of receipts over expenditures of $3,048.95; and there was a small increase in the net membership. There was a considerable increase in the size of the Proceedings; but the volume of matter printed in the seven bulletins ending with the issue of March 1942 was appreciably smaller than in the previous seven bulletins.

An increase in the sale of publications, stimulated largely by defense activities, has very nearly depleted the stock of loose-leaf Manuals printed in 1936, so that the schedule of reprinting which was started last year will have to be completed within the next three months.

The program for a complete revision of the Trackwork Plans, undertaken jointly by the Committee on Track and the Manganese Track Society in 1939, will be brought to a conclusion with the approval of the remaining 22 plans and the revised specifications at the meeting of the Association on March 18.

Finances

The Association closed its fiscal year of 1941 with an excess of receipts over expenditures of $3,048.95, which represents the largest addition to surplus since 1937 when sales of the then new loose-leaf Manual increased receipts to a level of $6,479.17 above the expenditures. As in previous years, the variation of the annual income and outgo of the Association's funds has been due to the influence of special items—the regular elements following a rather fixed pattern; and, what is more significant, the "special" items are concerned almost exclusively with publications.

Comparison of Receipts and Disbursements for a Seven-Year Period

		Disbursements		
	Receipts	*Normal*	*Manual**	*Track Plans*
1935	$29,001	$25,311	$4,799	
1936	28,643	25,050	9,612	
1937	36,523	23,605	8,595	
1938	28,422	23,394		
1939	28,189	22,969		$ 878
1940	28,272	24,000	665	1,786
1941	32,433	24,972	2,154	2,258

* Outlay for loose-leaf Manual, except cost of annual supplements.

In the case of income, there have been pronounced deviations from the normal pattern in only two recent years—1937 (referred to above) and 1941, when revenues were increased by sales of the revised track plans to the amount of $3,712.96. This is demonstrated by the table of receipts and disbursements for a seven-year period, which shows also how the variation in expenditures has been influenced by the size of the printing bill.

Thus, it is seen that the operations of the Association have been affected largely by the requirements of two primary services, the Manual and the Portfolio of Trackwork Plans. Through 1935–36–37 the work of editing and printing the loose-leaf Manual was responsible for very heavy expense. Depletion of the stock of these Manuals is now requiring a reprinting program which has cost $2,819 to date and will call for an outlay of more than $3,000 in 1942.

It is coincidental that the need for reprinting the Manual occurs just at the time when the Committee on Track is engaged in a complete revision of the Trackwork Plans which was started in 1939 and will be completed this year at a total outlay of about $6,500. However, the outlay for the latter was offset to some extent by proceeds from the sale of the plans, and this may be true in some measure this year; but the fact remains that the outlook for 1942 indicates that expenditures may exceed revenues by as much as $4,000 unless concerted efforts are initiated to effect every possible economy.

Except for this temporary upset of the Association's policy of maintaining a balanced budget, the finances of the AREA are in a thoroughly sound condition. The cash position has been such as to warrant the outlay of $10,000 recently for the purchase of U. S. Defense Bonds.

Membership

The membership record of the Association for the period from March 1, 1941, to March 1, 1942, was as follows:

Members on rolls as of March 1, 1941		1,909
New members		113
Reinstatements		22
		2,044
Lost by death	35	
Resigned	28	
Dropped	38	101
		1,943
Net gain	34	
Membership as of March 1, 1942		1,943

The composition of the membership as of March 1, 1942, compared with March 1, 1941, is as follows:

	1941	*1942*
Life	151	168
Member	1,462	1,466
Associate	269	272
Junior	27	37
	1,909	1,943

The growth in the roster of Junior Members, a new grade established by an amendment of the constitution in 1940, has not measured up to the sanguine hopes of those who fostered it. But until young men are relieved of the grave responsibilities that they face in these trying times, there can be no fair test of the possibilities of this innovation.

The increase in the roll of life members is also consistent with the normal trend. A state of balance with respect to the ratio of life members to total members will not be attained for several years to come.

While the membership has shown a small increase during the last 12 months, even this small rate of growth has been possible only because the number of new members from within the United States has exceeded the decline in membership in other countries. In Canada, a state of war for a period of more than two years has imposed a serious barrier to the inception of the new memberships necessary to offset the natural losses; while chaotic conditions elsewhere in the world have either made cancellations imperative or imposed serious obstacles to the continuation of membership. The net result has been that, whereas membership within the United States increased 43, there was a loss of 9 memberships in other parts of the world.

The trend over a greater period is indicated in the table showing the membership in various parts of the world on March 1, 1942, compared with March 1, 1935, that year having been selected because it marks the end of the period of marked decline in membership occasioned by the depression.

	1935	*1942*	*Incr.*	*Decl.*
United States	1,684	1,791	107	
Canada	104	97		7
Central and South America	38	32		6
Europe	19	7		12
Asia and Australia	55	15		40
Africa	3	1		2
	1,903	1,943	107	67

This shows that there was an increase of 107 in the number of members in the United States, but owing to a loss of 67 members in other countries the increase in the total membership amounted to only 40.

According to information made available to the secretary, 20 members of the Association are in military service.

The Association suffered the loss of 30 valuable and revered members during the last 12 months, among whom were R. H. Ford, past-president, and G. R. Smiley, director. Particular reference may be made also to O. E. Hovey, for many years an esteemed member of Committee 15; P. M. Gault, a signal engineer whose counsel and enthusiastic interest were greatly appreciated by the members of Committee 9—Highways, and Committee 10—Signals and Interlocking; and J. A. Parant, who played an important part in the work of Committee 16—Economics of Railway Location and Operation, and Committee 22—Economics of Railway Labor.

Publications

Bulletins—The number of pages in the seven bulletins ending with Bulletin 431 for March, 1942, was 865, which compares with 1,282 pages for the seven bulletins ending with March, 1941, and 987 pages in the preceding seven bulletins. The reason for this sharp reduction is due partly to the decrease in the number of pages required to print the current reports of the committees, from 656 pages to 582 pages, but primarily to the fact that several large special reports were presented for publication in 1940, whereas special material available during the last year was confined to monographs of modest length. The contents of the last two "summer" bulletins are listed below:

Bulletin 425, June–July, 1941

A Study of Corrosion of Rail and Track Fastenings in the Moffat Tunnel—A. E. Perlman
From a Woman's Viewpoint—Olive W. Dennis
Rail Corrugation—H. H. Morgan
Fine Aggregate Grading—Duff A. Abrams
Preliminary Report of Committee 3—Ties
Annual Report on Stresses in Railroad Track

Bulletin 426, September–October, 1941

Influence of the Fatigue Strength of Structural Members Upon the Design of Steel Bridges—W. M. Wilson
Fuel Economy From the Viewpoint of the Water Engineer—R. C. Bardwell
Research Work Covers Broad Field
The Relation of Transition Curves to Speed and Superelevation—O. E. Selby
Foundation Consciousness—E. R. Lewis

Proceedings—The magnitude of the printed matter appearing in the bulletins for the year ending with March, 1941, was, of course, reflected in the size of the 1941 Proceedings (Vol. 42), which contained 1,166 pages and was the largest book in any year since 1935 when the total number of pages was 1,214. By the same token, Vol. 43 will probably contain not more than 800 pages.

Manual—Progress in the revision of the Manual is shown in the table of annual supplements. However, it is necessary to bear in mind that supplements in alternate years differ in size because of the practice of issuing a complete new alphabetical index only in alternate (even) years. Omitting these index pages from the count, the 1941 supplement was the next to the largest issued to date. On the other hand, it resulted in the smallest net increase in the size of the Manual—only 28 pages.

Supplement	*New Sheets Issued*	*Old Sheets Withdrawn*	*Net Increase*
1937	110	69	41
1938	151	121	30
1939	128	95	33
1940	185	139	46
1941	148	120	28
Total	722	544	178

During the last year 180 copies of the complete Manual were sold, bringing the total distribution to 2094 copies. Thus, it is seen that the augmented demand stimulated by the defense program has continued unabated. Therefore, the program for the reprinting of the Manual, which was started during 1941 by placing the eight most popular chapters on the press, will be completed none too soon when the remaining chapters are rerun early this coming summer.

Confronted with five years' experience in keeping the Manual up to date by the printing of the annual supplements, and with the current need of replenishing the stock, together with a realization of the rising costs of paper and printing, the Board of Direction was faced with the prospect of a progressively increasing deficit from the business of producing and selling Manuals and was compelled, therefore, to authorize increases in prices, as of January 1, 1942, as follows:

Complete Manuals with covers:

	Old Price	*New Price*
Regular price	$10	$12
Special price to railroads	7	8
Price to members, first copy	4	5

The prices for chapters and parts of chapters, set up late in 1940, have not been changed.

By reason of a movement, now in its inception, for the emergency revision of specifications with the object of conserving limited supplies of certain critical materials, arrangements are being made to issue riders on colored sheets setting forth the nature of such emergency revisions, which are to be effective only for the duration of the war. More complete information regarding such revisions will be presented in the June–July bulletin.

Trackwork Plans—With the completion during the last year of 22 additional plans and the revision of the specifications for trackwork, which are being presented for adoption at the annual meeting this year, the Committee on Track has substantially completed its task of revising the Portfolio of Trackwork Plans begun in 1939 in collaboration with representatives of the Manganese Track Society. Including the 87 plans previously revised, together with a table of contents and a glossary of terms, the portfolio as revised will embody about 130 pages.

Work of the Committees

By action of the Board of Direction at meetings on March 10, and 13, 1941, two committees were discontinued; namely, the Special Committee on Stresses in Railroad Track and the Committee on Rules and Organization. In lieu of the former, the Board created the Committee on Research Administration; but because the duties of this new committee are solely administrative and advisory, it is answerable only to the Board and is, therefore, not counted among the 25 standing and special committees. One other change authorized at the same time was the transfer of the Special Committee on Clearances to the status of a standing committee with the designation of Committee 28.

This change in the committee setup is primarily responsible for the reduction in the committee personnel, from 660 individuals to 650. Of this number, 515 serve on only one committee, 105 are on two, 26 are on three, and 4 members are enrolled on four different committees. In considering this multiple committee service, it is necessary to keep in mind that the 136 men who serve on more than one committee include the 23 chairmen enrolled on the Committee on Standardization (12 of whom are also listed on the Committee on Clearances), and the 15 members of the Committee on Waterproofing as well as the 14 members of the Committee on Impact who are representatives of other committees. The rosters of 12 committees were reduced by a total of 17 owing to the death during the year of 14 members, one of whom was enrolled on three committees and another on two.

Reports were prepared by 25 of the 26 committees, there being no occasion this year for a report of the Committee on Clearances. These 25 reports were published in Bulletins 427 to 430, inclusive, and embrace individual subcommittee reports on 115 subjects. These reports were prepared under the direct supervision of 98 subcommittee chairmen, of whom six were responsible for two subjects each, two for three subjects, another for four, and still another for five.

The diversity of interest in the work of the committees is manifested also by the fact that the personnel includes representatives from 81 individual railroads. In addi-

tion, there are 24 members of the faculties of engineering schools, 23 engineers in private practice, 4 employees of railway associations, 6 editors of engineering journals, 9 representatives of trade associations and 45 engineers or chemists in the employ of railroad supply companies.

It is a matter worthy of record in this connection that the committee roster includes one man who has been identified with and continues to be an active member of one committee since the AREA was organized in 1899; namely, E. E. R. Tratman of the Committee on Yards and Terminals. With records nearly equaling his are J. C. Mock and A. H. Rudd, who have been members of the Committee on Signals and Interlocking since 1901.

Perhaps of greater significance is the diversity in the nature of the matter submitted in the reports. The committees had been given a total of 210 subject assignments; and as stated above, reports were presented on 115 of them. While it is impossible to set up any rigid classification of the material offered, the following is indicative of the character of the material submitted this year and last.

	Number of Reports	
	Last Year	*This Year*
Revision of the Manual—Minor	13	6
Revision of the Manual—Major	8	12
New Manual material—Minor	5	2
New Manual material—Major	7	11
New Manual material—Tentative	8	5
Information—with brief conclusions for Manual		2
Information	50	41
Reports of research work	9	10
Statistical data	5	6
Mathematical studies	5	1
Bibliographies	3	3
Brief reports of progress	15	17
	128	116

Research Work

Work on a number of important committee assignments is being advanced and materially aided by investigations and tests that have been made possible by appropriations of the Association of American Railroads. The research projects and the amount of money authorized for the various items during the last three years are shown in the following table. However, it is necessary to bear in mind that the full amount has not been expended in all cases.

	1940	*1941*	*1942*
Rail failure statistics	$ 5,400	$ 5,400	$ 5,832
Transverse fissure investigation*	22,500	9,000	9,000
Stresses in railroad track**	23,000	18,000	
Rolling-load tests of joint bars***	....	....	5,000
Tests of joint bars	3,500	3,500	2,500
Tests of manganese frogs****	1,000	1,000	1,000
Tests of bolt tension	600		
Impact in bridges	4,000	11,500	14,500
Fatigue tests of structural welds	....	5,000	5,000
Tests of waterproofing materials	....	500	750
Relation of track and equipment	....	32,500	35,000

* AAR contribution is matched each year by rail manufacturers.

** Activities under this head as and when needed are now carried on under special assignments.

*** Continuation of work conducted by Stresses in Track staff in 1940–41.

**** No money spent for this purpose in 1940–41.

Attention is directed to the consolidation of the administration of research work largely under the direction of Mr. G. M. Magee, research engineer, following the resignation of Dr. A. N. Talbot as chairman of the Committee on Stresses in Railroad Track and the termination of the work of that committee. The new Committee on Research Administration, to which reference is made elsewhere consists of the following:

H. R. Clarke (chairman), Burlington Lines
Louis Yager (vice-chairman), Northern Pacific
W. J. Burton, Missouri Pacific
W. F. Cummings, Boston & Maine
C. J. Geyer, Chesapeake & Ohio
J. B. Hunley, New York Central
F. R. Layng, Bessemer & Lake Erie
W. H. Penfield, Milwaukee
C. E. Smith, New York, New Haven & Hartford
A. N. Talbot, University of Illinois

W. S. Lacher,
Secretary.

Deceased Members

E. C. Alexander
Chief Engineer, Massey Concrete Products Company, Chicago

N. L. Arbuckle
Assistant Engineer, Cleveland, Cincinnati. Chicago & St. Louis Railway, Indianapolis, Ind.

W. J. Backes
Consulting Engineer, Boston & Maine Railroad, Bedford, Mass.

F. H. Bagley
Superintendent Telegraph and Signals, Seaboard Air Line Railway, Norfolk, Va.

L. H. Bond
Retired Chief Engineer Maintenance of Way, Illinois Central System, Chicago

H. O. Brown
Chief Engineer, Sacramento Northern Railway, Sacramento, Calif.

W. C. Brown
District Engineer, Missouri–Kansas–Texas Railroad Company of Texas, Denison, Tex.

Robert Farnham
Assistant Chief Engineer, Eastern Region, Pennsylvania Railroad, Philadelphia, Pa.

F. A. Feikert
Division Engineer, Southern Pacific Company, Ogden, Utah.

Robert H. Ford
Retired Chief Engineer, Chicago, Rock Island & Pacific Railway, Chicago

P. M. Gault
Signal Engineer, Missouri Pacific Lines, St. Louis, Mo.

J. G. Gwyn
Retired Chief Engineer, Denver & Rio Grande Western Railroad, Denver, Colo.

Otis Hovey
Consulting Engineer, New York City

M. B. Kent
Division Engineer Terminal, Missouri Pacific Lines, Houston, Texas

W. S. Kinnear
Retired Consulting Engineer, Grosse Point, Mich.

Deceased Members

H. A. Lane
Chief Engineer, Baltimore and Ohio Railroad, Baltimore, Md.

Henry Lehn
Retired Disbursement Accountant, New York Central Lines, New York City

C. O. Long
Division Engineer, Pennsylvania Railroad, Ft. Wayne, Ind.

A. D. McDonald
President, Southern Pacific Company, San Francisco, Calif.

M. McKimmey
Resident Engineer, Missouri & Arkansas Railway, Harrison, Ark.

J. M. Metcalf
Assistant Chief Engineer, Missouri–Kansas–Texas Railroad, St. Louis, Mo.

R. E. Nelson
Assistant Professor of Railway and Highway Engineering, West Virginia University, Morgantown, W. Va.

C. B. Nolte
President, Crane Company, Chicago

J. A. Parant
Assistant to Chief Engineer, Boston & Maine Railroad, Boston, Mass.

O. V. Parsons
Assistant Engineer, Norfolk & Western Railway, Roanoke, Va.

T. S. Pattison
Division Engineer, Chesapeake & Ohio Railway, Ft. Thomas, Ky.

H. J. Pfeifer
Consulting Engineer, Terminal Railroad Association of St. Louis, St. Louis, Mo.

H. D. Pollard
President and General Manager, Central of Georgia Railway, Savannah, Ga.

G. W. Rear
Engineer of Bridges, Southern Pacific Company, San Francisco, Calif.

G. R. Smiley
Chief Engineer, Louisville & Nashville Railroad, Louisville, Ky.

A. H. Utter
Retired Assistant Engineer, Chicago, Burlington & Quincy Railroad, Lincoln, Nebr.

Einar Weidemann
Engineer of Bridges and Buildings, Pennsylvania Railroad, Chicago.

E. H. Weinke
Assistant Engineer, Northern Pacific Railway, Glendive, Mont.

A. Ziesing
Scully Steel and Iron Company, Chicago

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1941

Balance on hand January 1, 1941		$87,137.88

RECEIPTS

Membership Account		
Entrance Fees	$ 905.00	
Dues	17,937.54	
Binding Proceedings	1,450.48	
Sales of Publications		
Proceedings	998.89	
Bulletins	1,267.30	
Manuals	2,159.79	
Specifications	828.00	
Track Plans	3,712.96	
Advertising		
Publications	1,196.40	
Interest Account		
Investments	1,890.75	
Miscellaneous	85.52	
Total	$32,432.63	

DISBURSEMENTS

Salaries	$ 8,315.00	
Proceedings	3,813.43	
Bulletins	3,821.45	
Stationery and Printing	1,112.19	
Rents, Light, etc.	780.00	
Supplies	79.56	
Expressage	4.48	
Postage	515.49	
Exchange	90.03	
Annual Convention	1,127.95	
Refunds, dues, etc.	123.50	
Audit (year 1940)	200.00	
Pensions (E. H. Fritch, A. K. Shurtleff)	2,460.00	
Social Security Act	78.12	
Manual Supplements	2,944.64	
Track Plans	2,258.29	
Miscellaneous	330.36	
Committee and Officer's Expense	121.36	
Unemployment Insurance—1937–1941	1,207.83	
Total	$29,383.68	
Excess of Receipts over Disbursements		$ 3,048.95
Less loss on bonds called for redemption during year 1941		345.00
Balance on hand December 31, 1941		$89,841.83

REPORT OF THE TREASURER

To the Members:

Balance on hand January 1, 1941		$87,137.88
Receipts during 1941	$32,432.63	
Paid out on Audited Vouchers	29,383.68	
Excess of Receipts over Disbursements		3,048.95
Less loss on bonds called for redemption during 1941		345.00
Balance on hand December 31, 1941		$89,841.83
Consisting of		
*Bonds at cost	$57,433.93	
Cash in Northern Trust Company Bank	30,611.05	
Cash in Royal Bank of Canada	1,771.85	
Petty Cash	25.00	
	$89,841.83	

Respectfully submitted,

W. H. Penfield, *Treasurer.*

We have made an audit of the accounts of the American Railway Engineering Association for the year ending December 31, 1941, and find them to be in accordance with the foregoing statements.

E. Deming,
C. G. Rivers,
Auditors.

GENERAL BALANCE SHEET

December 31, 1941

Assets	1941	1940
Due from Members	$ 673.00	$ 900.00
Due from Sales of Publications	43.35	33.80
Due from Advertising	93.00	51.00
Furniture and Fixtures	483.99	537.77
Publications on Hand (estimated)	1,250.00	1,500.00
*Investments (cost)	57,433.93	75,945.81
Interest on Investments (accrued)	432.61	609.80
Cash in Northern Trust Company Bank	30,611.05	10,331.23
Cash in Royal Bank of Canada	1,771.85	835.84
Petty Cash	25.00	25.00
Manuals (on hand)	2,400.00	1,800.00
Trackwork Plans	800.00	800.00
Total	$96,017.78	$93,370.25
Liabilities		
Members' Dues Paid in Advance	$ 5,581.00	$ 5,300.50
Surplus	90,436.78	88,069.75
Total	$96,017.78	$93,370.25

* Includes $6,240.00 book value of Rock Island, Arkansas & Louisiana 4¼% bonds due March 1, 1934, not paid, in default.

Also includes St. L. S. W. 5% bonds, book value $1,319.31, interest coupons January 1, 1936 and thereafter in default.

United States Treasury Bonds book value $18,511.88 called for redemption at $18,166.88 and accrued interest during year 1941. (Loss $345.00)

Discussion on Standardization

(For Report, see pp. 25–36.)

(President Bond presiding.)

Chairman F. L. Nicholson (Norfolk Southern): The first subject to be reported on by this committee is: What AREA recommended practices should be advocated for general use on railways.

The committee feels it almost unnecessary to call the attention of the Association to the excellent recommendations contained in the Manual, but it is also known that many of our members do not adopt these recommended practices. Some adopt them in whole; others only in part.

Your committee, in order to aid the members in their selection of subjects to be adopted, submitted a tabulation of recommended practices thought adaptable to general use on railways in the interest of uniformity of practice, economy and efficiency at the convention of 1937 and again in 1940. Because of general conditions now affecting materials and labor, we now submit to you a revised tabulation and most earnestly ask favorable consideration for adoption by those who have not already done so. If it has not already been done, we again urge consideration of these practices. They are listed on pages 26 to 30. We believe that the present difficulties warrant the adoption of uniform practices as never before.

The second subject: What AREA recommended practices should be sponsored as subjects for national standardization. Of course, many practices adopted by this Association are not suitable for that purpose.

(Chairman Nicholson read the two paragraphs appearing under Assignment 2.)

Chairman Nicholson: Decision as to further action on these matters will probably be made by the Board of Direction.

The third subject: Maintain contact with standardization bodies and keep the Association informed on important matters developed by such contact.

(He then read the report on Assignment 3.)

President Bond: I would like particularly to emphasize Mr. Nicholson's remarks regarding the supreme importance at this time of following standard practices in order to eliminate production and material difficulties.

If there is no further discussion, the report will be accepted and the committee will be excused with the thanks of the Association. (Applause)

Discussion on Electricity

(For Report, see pp. 37–39.)

(President Bond presiding.)

Chairman H. F. Brown (New York, New Haven & Hartford): The report covers two assignments: 1—Developments in the application of electricity to railway service; and 2—Principal current activities of the Electrical Section, Engineering Division, AAR.

(He read the report on Assignment 1.)

Chairman Brown: I can report that this is so because on our railroad we have already broken the 1929 records twice within the last two months.

The report on Assignment 2 is a brief abstract of the principal current activities of the Electrical Section, Engineering Division, AAR. Copies of this report in full can be obtained from the secretary.

(He then read the report on Assignment 2, with the following interpolations:

I might say in passing that the work of the Committee on Overhead Transmission Line and Catenary Construction has been most important. The members of the Electrical Section who collaborated with the committee on the revision of the National Electrical Safety Code have really done a monumental piece of work. It is due to the efforts on the part of the members of our Association that this code was finally adopted in its revised form.

The final report of the Electrical Section includes in its discussion, at its annual meeting in November, two very comprehensive papers by Messrs. Helmbright and Hibben, dealing with fluorescent lighting. These are mentioned as of interest to this Association.

The report on the tests which have been conducted at Lambert Point on the Norfolk & Western, when completed, will be a really monumental work in research and of value to all of the members of this Association who are interested in corrosion.

This report is submitted as progress.

President Bond: If there is no discussion, I would like to take this occasion to thank Mr. Brown and the committee very much for the extremely able report and for the very interesting résumé of the work what was done by the Electrical Section of the Engineering Division.

Discussion on Signals and Interlocking

(For Report, see pp. 41–46.)

(President Bond presiding.)

Chairman H. G. Morgan (Illinois Central): It is with deep regret that I have to announce the loss of a third member of Committee 10. Mr. F. B. Wiegand passed away yesterday morning.

The report of Committee 10 will be presented by the subcommittee chairman, Mr. Post.

W. M. Post (Pennsylvania): Under Assignment 1—Developments in railway signaling—we are reporting on first, a centralized traffic control and telephones on the same pair of line wires, second a yard communicating system and third a new feature of the coded track circuit control, the "Reverse Code".

The first report on Assignment 1—Development in railway signaling—is CTC and telephones on the same pair of line wires. This development is of considerable importance at this time in that it makes possible a considerable saving in copper. A coded circuit is required for the entire length of the CTC territory. If a pair of existing telephone wires is of sufficient size for mechanical strength and well constructed, they can be used. If not, the wires can be replaced by wires of larger gage, and the existing wires can be salvaged. If an additional telephone line is needed, the wires can be of sufficient gage, well constructed, and the CTC circuit superimposed on the additional pair of telephone wires.

The second report is: Yard communication system. This system makes possible telephone communication between yard office and switching engines which results in reducing idle time of the engines and speeds classification of cars. The system described is not radio, and does not require permits for installation nor licenses for its operation and maintenance. The same results can be accomplished by radio communication, which is in use for this purpose in the switching territory at the Elwood ordnance plant near Joliet, Ill., and, I understand, is contemplated at other ordnance plants.

The third report is on the reverse code in coded track circuit. This is another development that conserves copper. The usual practice in automatic signal territory is to use line wires for approach lighting or other control circuits. The coded track circuit is usually fed to the exit or leaving end of the track circuit, and the relay which responds to this track circuit is located at entering end. The reverse code provides, in addition, for coded energy to be fed at the entering end of the track circuit, and the relay which responds is located at the leaving end. This provides two coded track circuits in opposite directions operating simultaneously over the same pair of rails, permitting the use of the reverse track circuit for approach lighting or other control circuit, and thus reduces and, in some cases, eliminates the need for line wires.

The report on Assignment 2 reviews the principal current activities of the Signal Section and is found on page 43.

Attention is called to the series of pamphlets on American Railway Signaling Principles and Practices prepared for the education of those desiring to study this subject. You will note 23 chapters in the series of 24 have been completed. They can be obtained by writing to the secretary of this Association or from Mr. R. H. C. Balliet, secretary of the Signal Section, 30 Vesey Street, New York. The cost for the 23 chapters is $5.80 for railroad employees and $8.25 for others. The cost per chapter varies from 10 cents to $1 for railroad employees and from 20 cents to $1.25 for others.

There are 26 items outlining work which has been performed since our last report. The reports on these items can be found in the Proceedings of the 1941 annual meeting of the Signal Section.

The first 9 items cover economics of signaling.

Item 4—Freight train saving when trains are operated by signal indication: In the report on this subject it is stated that, after a CTC system was in service in place of manual block on 21 miles of single track and 7 miles of double track, Machias to Jamison Road, New York, on the Pennsylvania Railroad, the average time saved per freight train was 28.6 min. which was 29.4 percent of the freight train time.

Attention is also called to a CTC system replacing a manual block on 12 miles of single track between Hudson and Arlington on the Pennsylvania Railroad in which the average time saved per freight train was 12.56 min. which was 28.8 percent of the freight train item.

Item 5—Freight train time saving where trains are operated by automatic block signals: This report sets forth the benefits from continuous coded cab signals (without automatic wayside signals) on 50 miles of double-track freight line between Conpitt Junction and Kiski Junction, Pa.) on the Pennsylvania Railroad. The average time saved per freight train was 17.8 percent..

Item 7—Economics of revision of automatic block signal spacing incident to greater braking distance: The savings are mainly the saving of power purchased from commercial power companies, primary batteries and repairs of signals eliminated. The C. M. St. P. & P. R. R. estimated an annual saving of 16 percent on the total cost of respacing signals between Chicago and St. Paul, Minn., a distance of 405 miles double track, and a return of 140 percent on the total cost of respacing signals between Chicago and Savanna, Ill., a distance of 121 miles double track. The Illinois Central Railroad estimated an annual saving of 36.2 percent on the total cost of respacing signals between Branch Junction and Cairo, Ill., a distance of 115 miles double track.

Item 9—Train hour value: This is a short report stating that the committee is attempting to set up a definite basis for investigation by arriving at a comprehensive list of factors entering into the cost of a train hour, whether tangible or intangible.

Item 12—Interstate Commerce Commission order covering manual block signal systems. This report is a copy of the "Show Cause" order of the ICC covering Rules, standards and instructions for the installation, inspection, maintenance and repairs of manual, controlled manual and staff block system, together with a copy of the reply from the attorneys representing the AAR.

Item 14—Possibility of improper signal operation resulting from the use of rail fissure detector cars and recommended protective measures: After discussion of the effects of AAR, Sperry or magnetic types of rail fissure detector cars on signal operation, Committee 4 (Signal Section)—Automatic Block Signaling—presented the following conclusions as information:

(a) That rail fissure detector cars can be operated with safety under automatic block rules in alternating-current track circuit territory with alternating current track relays, since the shunt appeared to be perfect.

(b) That rail fissure detector cars cannot be operated with safety under automatic block rules in territory where direct-current track circuits and direct-current track relays of the neutral or polarized type are used, and that special precaution must be taken because of the amount of direct current observed to be flowing through the track relay.

Item 29—Operation of highway crossing protective devices at crossings where a train stops on the operating circuit and does not approach the crossing in a single continuous move: This report contains suggestions for protection of highway grade crossings when train or cars are standing on approach circuit and also outlines several special arrangements now in use to minimize operation of crossing signals when train stops or cars are being shifted on the approach circuit.

The rest of the report contains list of specifications, requisites, drawings and other matters which have been submitted to letter ballot by the Signal Section.

President Bond: If there is no discussion, we will thank the committee for the excellent report which has been submitted. (Applause)

Discussion on Economics of Railway Location and Operation

(For Report, see pp. 49–71.)

(Vice-President Clarke presiding.)

Chairman H. M. Stout (Northern Pacific): The assignment to this committee in the past year has included 12 subjects. Collaboration with other committees of this Association or other divisions of the AAR was specified in the consideration of three of the subjects. Also, this committee was asked to collaborate in the study of two subjects assigned other standing committees of this Association. All of these assignments have been accepted, and due consideration has been given to them during the year.

The report of this committee being presented includes progress reports submitted as information on two of the assigned subjects as published; also, a brief discussion on two additional topics will be given.

The first subject assigned is: Revision of Manual. In our report last year it was stated that the subcommittee organized for the consideration of the revision of Chapters 16 and 21 of the Manual had undertaken the review and the revision of the important subject: The cost of stopping and starting trains. It was anticipated that a report on this subject would be developed and made available at this time, but that was found impossible. Mr. E. E. Kimball, chairman of the subcommittee handling this study, is present and will discuss some of the features of this important topic.

E. E. Kimball (Schenectady, N. Y.): The cost of stopping trains has been taken care of by the Signal Section of the AAR., which has already published a report and some curves. We are going along with that until we can get more information and a better chance to determine how it differs with different types of locomotives. That is about all we can report at this time.

(At this point Chairman Stout presented a brief review of current progress on the various assignments on which no report was presented.)

Chairman Stout: Assignment 9—Train resistance of freight trains under various conditions of loading and speed. In the report of the committee last year, the first presentation of information on this subject was given. This consisted of a survey and résumé of the more important work which had been done in the establishment of general resistance formulas. A second report of information is now offered.

Mr. L. K. Sillcox, chairman of the subcommittee, cannot be present at this time; and in his absence, I am going to ask Mr. Mannion, vice-chairman of this committee, to present the report. He is also a member of the subcommittee.

M. F. Mannion (Bessemer & Lake Erie): Since the Forty-second annual convention of the Association, this subcommittee has concluded its Assignment 9—Train resistance of freight trains under various conditions of loading and speed. The objective of our efforts has been the submission of a preferred general method for calculating train resistance; and our procedure has been to investigate the literature of the art, evaluating available data, analytical as well as those developed by experience or test, to determine if, in our opinion, they justify a revision of the now recommended Davis formulas as they appear in the Manual.

AREA train resistance references: As a consequence of our stated procedure to investigate the literature of the art, the Proceedings of the Association were searched for any material which might possibly affect our conclusions. With the thought that a bibliography of articles dealing with the various train resistance components might be of assistance to subsequent investigators, one covering the Proceedings, Vol. 10, for 1909 and following years, was compiled and appears on page 51.

Effect of track modulus: The effects of rail weight and modulus of elasticity of rail support were investigated and a factor derived which may be incorporated in the Davis formulas by anyone electing to allow for variations in rail weight and rail support. The factor is based upon an analysis which is published, beginning on page 419, Vol. 38, of the Proceedings for 1937. In effect, the derived factor reduces the unit train resistance obtained by application of the Davis formula by an amount equal to that chargeable to rail and rail support of assumed average track and then adds a similar value for the track involved. The three variables which influence track effect are: The modulus of elasticity of rail support, rail weight and moment of inertia. The application of the derived factor assumes standard track to be laid with 112-lb. rail with a moment of inertia of 65.8 in. to the fourth power, and with a modulus of elasticity of rail support of 2,500 lb. per inch of length per inch of depression. The effect of this component upon unit train resistance on a large percentage of the track laid in this country and Canada is relatively small and is considered an unnecessary refinement in most instances.

Effect of air conditioning: The influence of the air conditioning load was injected into this freight car analysis only for the reason that there appears to be a growing trend toward axle-driven air-circulation fans in refrigerator cars, and mechanical refrigeration may become a common development at some future time. The effect of adding a generator load, which also may be interpreted as axle drag from any cause, was investigated and a factor derived which permits the calculation of the increased

train resistance developed by 15 and 20-kw. loads over that of a 4-kw. generator. This method is not valid for load conditions varying from those upon which the factor is based, and a substitute term must be employed in such instances.

Effect of atmospheric temperature: A determined effort was made to establish a rational method for modifying the Davis formulas to introduce the effect of atmospheric temperature variation. Tests data were examined and a factor derived, based upon those data. It is the judgment of this subcommittee that this factor is insufficiently supported to warrant its employment in determining locomotive tonnage ratings and was presented as information only. The effect of temperature is not a fixed variable. It is greater on a low grade line with maximum tonnage trains, and it may be much greater in regions where low temperatures are generally associated with high winds and drifting snow. However, inquiries were addressed to all members of Committee 16, with respect to the practices of the railways represented in the establishment of correction factors, variable with atmospheric temperature, on tonnage rating of freight trains. Data submitted were recorded graphically, plotting the temperature ranges within which various percentages of normal tonnage ratings were applied. A relatively narrow band of values may be specified which will embrace practice in nearly all cases. An average curve could be constructed and its equation derived to produce an additional term in the Davis formulas; but an attempt to fix tonnage ratings in this manner might very well prove embarrassing; and there is serious question relative to such a procedure being in the best interest of the members of the Association.

Effect of lateral forces due to side winds: A method of determining the lateral forces developed by side winds of varying angularity and velocity has been derived. The problem does not lend itself to analysis, hence reliance must be placed upon such tests data as are available; and due to practical limitations, possible bases are further confined to laboratory tests as conducted in wind tunnels. Road tests are not feasible due to the large dimensions of railway equipment, the difficulties encountered in controlling the forces of nature in a precise manner, and the obstacles to separating the various components of the total resistance value. Such wind tunnel investigations as have been conducted to date have had as their primary purpose the measuring, comparatively, of drag forces as an aid in the selection of the most economical structure contour, beam component measurement being but of secondary interest. The increased wind tunnel sectional areas required when models are revolved from the longitudinal axis of the tunnel have acted as a deterrent to such experiments. The other alternative is a test model of decreased dimensions and, since the evaluation of drag was the primary object, hesitancy to sacrifice model size, with the consequent introduction of increased scale effects, is readily understood. The unfortunate result is, however, a dearth of test data derived from examination of the aerodynamic characteristics of railway equipment; and, therefore, in the analysis which was prepared, it was necessary to look to the automotive field for the verification of certain assumptions essential to the method. The derived formula was presented, not as a tool of every-day railway operation in assigning tonnage ratings under specified wind and operating speeds, but as information relative to the present state of the art and as a means of measuring lateral forces under various combinations of speed and angularity to demonstrate the importance of side wind resistance as a part of the whole. Despite the difficulties to be overcome in defining, on a logical basis, exact values of side wind resistance, and the constantly varying wind and locomotive directions as the train advances throughout its assigned run, it does not appear that this resistance component should be ignored when determining train resistance in the aggregate.

In view of the insufficiency of the data upon which the derived modifying factors are based, it is the conclusion of the subcommittee that no change be made in the Davis formulas at the present time.

This report is submitted as information.

Chairman Stout: I might add that, although this report, which I hope each one of you has read and followed the analysis—it is highly technical—finishes the survey of the field, and there is nothing left for the committee under the assignment, according to its interpretation, except possibly to gather up some general principles which could be recommended for inclusion in the Manual. It isn't at all certain that we will find any, but we would be very glad to reopen the subject if anyone after rereading or hearing the presentation finds that further discussion is merited.

Assignment 10—Development of modern power units and the effects on the economics of railway location and operation. This assignment has been under study during the past two years. The first progress report of information will now be presented by Mr. E. E. Kimball, chairman of the subcommittee.

E. E. Kimball (Schenectady, N. Y.): In general, American railroads have been built up around the steam locomotive, so that any track structures and line locations have been largely determined by the steam locomotive rather than any other type of motive power. The year 1914 seems to be a good time to start our comparisons. It was about that time that the superheater and the mechanical stokers came into vogue. Since then there has been a great deal of improvement in the steam locomotive.

This year we started collecting data to show the effect on track construction and such matters, and eventually we will probably get into Diesel-electric and electric operation.

Chairman Stout: The twelfth subject is: The advantage derived from stiffness of track in improving economics of train operation. The chairman of the subcommittee, Mr. H. F. Schryver, will present a report verbally.

H. F. Schryver (New York Central): An outline has been prepared as a guide which the subcommittee proposes to follow in making the report when it is felt it is advisable to write the concluding paragraph. This outline is divided into five major headings:

I. Economic Elements
II. Advantages
III. Disadvantages
IV. Consensus of Opinions
V. Conclusion—in which the outline now says parenthetically "Not yet."

The purpose of this subcommittee is to formulate a defensible determination from facts and surmisals.

In order to develop the pros and cons as regards stiffness of track, the resultant benefits can be better identified from a study of advantages which accrue to the various departments directly responsible for economical train operation.

Many of the advantages from substantial or strong track structure will naturally be reflected in the performance of more than one department; the advantage of higher operating speeds will not only reflect in reduced car hire cost, but will also produce tangible benefits from a traffic or sales standpoint.

By maintaining a track structure which includes sufficient and satisfactory ballast properly drained, suitable ties, heavier or stiffer rail, joints, frogs and switches, together with long life tamping, enabling such a structure to be put up in a semi-permanent form, the hazard from derailment due to defective track conditions and the develop-

ment of potential shearing shocks in rolling stock is markedly reduced. All of these items combine to produce the first necessary requisite for economical rail transportation, i. e., a substantial and smooth track structure over which trains are operated.

Increased operating speeds have permitted a resultant saving in the number of locomotives and cars necessary to handle the traffic offered. As the miles per car per day increase, the work that is performed by the individual car is increased, resulting in a less number of units being required to handle a given volume of traffic; and so also with respect to locomotives, inasmuch as each unit of motive power, by reason of shortened time between terminals, performs more work per unit of time, and is available for more trips. Direct train costs are reduced by minimizing or eliminating overtime in wages and saving in fuel.

Smooth and rugged track structure will reduce transit shocks to lading caused by defective track conditions, and will naturally reflect a benefit to the loss and damage statement, as well as contribute to the satisfaction of the shipper or consignee.

The advantages derived from stiffness of track in improving the economies of track maintenance are considerable. The larger part of rail renewals is brought about by worn joint conditions, lack of strength and stiffness. Given a sufficiently heavy rail with ample stiffness in both the rail and the joints, also otherwise good track conditions, a track structure will experience long life. This means a reduction in labor expense for such maintenance operations as smoothing, surfacing, lining, etc. The wear on crossties is reduced, thus reflecting a saving in tie renewals. Proper distribution of metal in rail sections has a notable effect on the resultant stiffness of the rail, and consequently of the track structure. The 131-lb. rail section adopted by the AREA, although containing only 1 lb. more to the yard than the 130-lb. section, has an increase in stiffness of 15 percent; and joint bars that are used are 43 percent stiffer than the bars used with the 130-lb. rail. The use of this increased and improved weight and section will produce economies in maintenance costs as well as insure smoother and faster train operation.

A track, capable of withstanding forces of distortion, being subjected to little line and surface variations, minimizes car sway or rocking motion, thus reducing the shearing shocks and fractures of metal on various parts of equipment. By reason of permitting increased train speeds, fewer units of equipment are now needed than formerly; consequently, the life of equipment is increased and the expense of repairs thereto is reduced.

The principal advantage to be derived from a traffic standpoint would be that of safety and service. In passenger train operation, security, speed, and ease are paramount. There is no question but what stiffness of track structure is contributive to a comfortable trip. The advantage of moving passengers and freight with safety and on-time performance is self-evident; particularly, in view of the competition afforded by other present day modes of transportation.

Increased operating speeds, which come from better, more stable, and sometimes called stiff track, permit patrons of the railroads to carry smaller inventories by bringing the producer nearer the consumer. The movement of traffic more rapidly, with fewer delays and less damage, attracts a greater volume.

The Railway Age in 1939 printed an article under the caption of "What Horsepower for 1,000-ton Passenger Trains?" This article reports on tests made by the Mechanical Division of the AAR to determine the maximum drawbar horsepower required at 100 m. p. h. on level tangent track.

These tests were made in October 1938, on the Pennsylvania, the Chicago & North Western, and the Union Pacific. The test train consisted of 16 cars (14 coaches, a baggage car, and a dynamometer car), all on four-wheel trucks; total weight of train, 1005.2 tons. Six different locomotives were used on the trip, between Ft. Wayne, Ind., and

Grand Island, Neb., covering 1,560 miles in the round trip. The observer, personnel, and crew, were the same throughout the tests.

Track structure varied in weight of rail from 100-lb. to 131-lb.; ballast materials: crushed limestone, cinders, gravel, stone, sand, slag, and crushed rock.

Several elements affecting the determination of the requisite power delivered at the drawbar are: (a) machinery friction, (b) rolling resistance, and (c) head-end air resistance.

The dynamometer car readings varied considerably, and the differences ostensibly convey the impression that over heavier rail on stone ballast less horsepower is required than over lighter rail on gravel ballast. The report is not conclusive.

Parenthetically we state with some hesistancy that the report is not conclusive; however, some members of this subcommittee and others with whom we have discussed the subject concur in this observation.

Some tests were made on the Kansas City Southern, and reports published in the Proceedings, Vol. 31, page 149, and Vol. 38, page 409, respectively, are informative and helpful. On the Boston & Maine a test was made (no report published) which consisted in hauling a train in one direction over a track having 130-lb. rail, and in the opposite direction over the second main track which was laid with 100-lb. rail. Unfortunately, on the return trip, interruption was experienced which precluded productive analysis of the results. However, usable data indicated between 5 percent and 7 percent less resistance on the 130-lb. rail track.

From an analysis of a study on track stiffness as regards locomotive capacity, it has been found for one of the heaviest locomotives (on the Milwaukee) followed by a 6,000-ton train on one track having 70-lb. rail, and on another having 131-lb., that the reduction of locomotive horsepower required to overcome the grade and other resistance is as follows:

M. P. H. Train Speed	HP. to Overcome Track Depression	Total HP.	Percent Reduction
20	363	3,220	11
40	726	3,770	19
60	1,089	3,620	30

Reference is made to the Proceedings, Vol. 19, page 1005–8; also to the details which illustrate the theory that "stiffness is the reciprocal of the depression due to unit load".

Recorded performance of experience with 131-lb. and 152-lb. rail shows (a) less unit stress, (b) fewer rail failures per mile, (c) more shallow penetration of tie plates into ties, and (d) an annual per mile saving in maintenance, in the future use of 152-lb. rail in 1,000 miles of heavy tonnage high speed track, of approximately $180,000.

The advantages of substantial track are undeniable, and increased annual cost is materially offset by the direct and ascertainable savings. It is quite possible, or even probable, that the indirect and unassignable savings are of even greater worth from a broad point of view than the direct cash savings. The margin of safety factor has been shown to increase much faster than the ratio of increase in weight. This, in itself, is a guarantee of fewer interruptions to traffic because of broken rails with resulting possible derailments or slow orders during renewals. In these days of fast and exacting schedules, time lost for any reason is difficult to regain; late arrivals and missed connections, as well as disruptions and interference with other train schedules, are costly. It is accepted that, other conditions being the same, a stiffer track permits higher speeds due to

reduction of rail undulations. These factors, while of immense value from a transportation standpoint, are difficult of exact analysis.

In the maintenance of way field, the stiffer track produces the most readily reflected economies. Progressive tests over long periods of time, as reported by some railroads, have demonstrated the economy of the more rigid track structure, specifically in the use of 131-lb. rail as compared to 100-lb. rail. An increase of 31 percent in weight has made possible a design which delivers an 80 percent increase in length of life with a possible 20 percent reduction in the direct labor cost of maintenance during the rail life. As labor rates advance, this saving is correspondingly greater.

Proponents of heavier rail say less hammer at the joints is experienced, minimizing batter and churning and ballast losses from this cause, thereby conserving labor and the additional ballast required in correcting bad joint conditions often found in lighter track. Others contend that experience establishes their position as tenable and that joints in heavier and stiffer rail are more susceptible of batter.

Basically it is sound business to invest so as to yield safety and comfort for passengers, reliable performance in handling freight and reduction in damage to lading. The loss of good will of the patrons is far-reaching; improvement of track structure reduces such loss.

Greater speed results in a reduction of over-all time on the road (or heavier train load without loss of speed) and worth while economies are generally obtained. It is not easy to estimate the amount of such economies, even in cases which are affected by particular known circumstances. Savings in the cost of maintenance of equipment, and in the cost of maintaining track and roadbed, on track consisting of heavy first-class materials as compared with track of lighter materials on soft roadbed, are sure to follow as a result of the better type of construction.

Thus far in this paper, the discussion has leaned toward increasing the stiffness of track, primarily by providing heavier rail. There is a "saturation" point beyond which rigidity backfires. High first costs may appear to be warranted theoretically; however, the vulnerable characteristics of adamant track structure, with consequent damage to rolling stock, equipment, and lading, tend to offset economies otherwise contemplated.

By mathematical analysis, it has been demonstrated that a train tonnage could be increased from 23 to 28 cars if 90-lb. rail were replaced with 152-lb. on ruling grades. This assertion, obviously, rests upon certain assumptions which are sensibly detailed. Executives, doubtless, would hesitate in authorizing an expenditure of 70 percent for additional weight of rail, in order to increase train tonnage by 20 percent. In the instant case, at $2 per train mile, an annual saving of $144,000 is stated as being possible. Be that as it may, it is worthy of note, that high grade track materials (and ample labor) other than rail, favorably contribute as much, if not more, effect on the tractive force required to overcome track depression. It is the opinion of some engineers that better and deeper ballast, longer and heavier ties, along with ample maintenance labor, produce greater savings than heavier rail.

The subcommittee withholds determination of any conclusion, pending further research to be based on factual information and the relative importance of dependable data.

If we may borrow one short phrase from the address by Mr. Eastman, I would like to quote: ". . . no time for old routines".

Chairman Stout: The report on Subject 12 is offered as information.

In conclusion, it is becoming, and my sad duty, to refer to the death of Mr. Joseph A. Parant, a member of this committee, assistant to the chief engineer of the Boston & Maine Railroad.

A brief in memoriam, including a sketch of Mr. Parant's career and active life is given on page 50.

This completes the report of Committee 16—Economics of Railway Location and Operation.

President Bond: I know the members of your committee are continuing to give serious consideration to the subjects assigned for study. We want to thank you very much for the reports that have been submitted. The committee is excused with the thanks of the Association. (Applause)

Discussion on Waterways and Harbors

(For Report, see pp. 47–48.)

(Vice-President Clarke presiding.)

Chairman G. P. Palmer (Baltimore & Ohio Chicago Terminal): The committee has only one assignment to report on this year, 6—Lands subject to servitude of navigation as affecting protection of roadbeds built or to be built on proposed dam pool areas. This will be given by Mr. Middleton, chairman of the subcommittee who will explain why it is recommended for inclusion in the Manual.

R. J. Middleton (Chicago, Milwaukee, St. Paul & Pacific): I would like to call particular attention to the fact that this report applies to navigation pools only, because questions have been asked about flood control, power projects, etc.

(He then read the report under Assignment 6.)

Mr. Middleton: It is recommended that this report be adopted for publication in the Manual. I so move.

(The motion was seconded, put to a vote and carried.)

Chairman Palmer: This concludes the report of the Committee on Waterways and Harbors.

Vice-President Clarke: If there is no further discussion, the committee is excused with the thanks of the Association. (Applause)

Discussion on Economics of Railway Labor

(For Report, see pp. 229–242.)

(President Bond presiding.)

Chairman G. M. O'Rourke (Illinois Central): Your committee offers final reports on five subjects, and a progress report on one. Four are submitted as information, and one includes a table presented for adoption.

A progress report on: Analysis of operations of railways that have made marked progress in the reduction of labor required in maintenance of way work, will be presented by Mr. H. A. Cassil, chairman of the subcommittee handling that subject.

(Mr. Cassil read the report on Assignment 2.)

Chairman O'Rourke: The next subject on which the committee is prepared to report is that of: Labor economies to be derived from stabilization of roadbed through means other than drainage. This report will be presented by Mr. McIlheran, chairman of the subcommittee.

E. H. McIlheran (St. Louis Southwestern): A summary of the report is as follows:

We sent a questionnaire to 48 railroads representing about 197,000 miles of railroad to ascertain the various methods, other than drainage, that are used to stabilize roadbeds, the cost of such work and the saving in labor derived therefrom.

The methods reported on are: Driving cull or old crossties or short poles in cuts or low fills; driving poles, piling or scrap rail in the shoulders of embankments; placing concrete slabs or wood mats on top of the roadbed; forcing cement grout into the roadbed and constructing banquettes along the toe of embankment slopes or widening the base of the embankments. These methods, with brief descriptions, costs and estimated savings are:

When the track continues to settle and heave and requires more than ordinary spotting, cull or old crossties or poles 7 to 10 in. in diameter and 8 to 12 ft. long or any timber of sufficient strength to withstand driving, are driven not to exceed 6 in. from the ends of the track ties with their tops 6 to 12 in. below the bottom of the track ties and spaced 18 to 21 in. apart. Reports were received on the driving of 326.26 miles of cuts and fills at an average cost of 61½ cents per foot of track and an estimated annual saving in labor of 19.37 cents per foot of track.

Poles, piling and scrap rail have been driven in the shoulders of embankments varying in heights from 8 to 40 ft., both to prevent settlement of the track and to cure sliding fills. The rail was used where the underlying foundation was rock and wood piling could not be driven. Reports were received on 20.63 miles of track driven with poles and piling in the shoulders of embankments at an average cost of $2.69 per foot of track and at an estimated annual saving in labor of about 72 cents per foot of track. Reports were received on 5.49 miles of track driven with scrap rail at an average cost of $8.79 per foot of track and at an estimated annual saving in labor of $2.31 per foot of track.

Reports were received on the installation of concrete slabs under 15,835 ft. of track, some of which were installed about 30 years ago; and there has been no trouble with the roadbed in this location since. Only one railroad furnished an estimated saving for the installation of concrete slabs and this showed the cost of construction was $3.99 per foot of track with an estimated annual saving in labor of about $1.20 per foot of track.

One railroad reported on the use of cypress timber mats on 6,642 ft. of track costing $2.69 per track foot, with an estimated annual saving in labor of about 81 cents per track foot.

Another railroad reported on the use of cement grout forced into the roadbed by air pressure on 472 ft. of track at an average cost of $3.49 per track foot, with an estimated annual saving in labor of $2.09 per foot of track.

Several railroads reported the use of banquettes but furnished no data as to cost or savings.

This report is submitted as information.

Chairman O'Rourke: After two years of study, your committee is presenting a review and revision of factors previously established for equating track values for labor distribution. This report includes a table and some conclusions presented for adoption.

Due to increased weights of materials and different types of materials,, such as asphaltic compounds for street crossings, road crossings, and very much heavier material in construction of turnouts and other factors affecting the conclusions of committees previously handling this subject, there are some slight changes. The table offered for adoption is on page 236. I shall read the conclusions.

(Chairman O'Rourke read the conclusions on page 238.)

Chairman O'Rourke: I move the adoption of the table and the conclusions.

(The motion was seconded, put to a vote and carried.)

Chairman O'Rourke: The next subject assigned this committee is: Labor economies possible through the use of highway motor vehicles for maintenance forces. When Mr.

J. A. Parant accepted the chairmanship of this subcommittee three years ago, he did it in a modest manner so characteristic of the man; those who knew him considered him an able engineer and a good friend. He said he hesitated because he was not sure of being able to do it justice but, having accepted it, he said he would do his best to get together facts. While on a week-end holiday last September, he became ill and was taken to a hospital at Wolfeboro, N. H., where he passed away. We shall miss him on Committee 22. The Association has lost a loyal member. He was a fine man, a good friend and an excellent engineer.

Mr. C. W. Baldridge will please present this subcommittee report.

C. W. Baldridge (Atchison, Topeka & Santa Fe): The increase in activities around large terminals and many yards has made it so difficult for track men to reach places of work by means of motor cars, that numerous railroads have been advocating the highway motor truck, or something of that sort to get their men to work. That is the essence of our work. The report reads as follows:

(Mr. Baldridge then read the report on Assignment 6.)

Vice-President Clarke from the floor: This is an excellent report. It has presented a good many arguments in favor of the use of motor trucks, which would certainly be very helpful to all of us who have been trying to secure these vehicles and have not always been able to convince our management that we should be supplied with them. But I wonder, in view of the present situation, if the report is complete. There are many good reasons for using trucks, but what are we going to do about them when we can't get them? That is the situation now. I merely raise that question and suggest to the committee and to other committees that, in view of the present emergency which confronts us, and the fact that every day brings changed conditions, all of us should be on the alert to keep right up to the minute, and make our reports of current value. It certainly would have been most helpful had this committee been able to come in and have said to us, "We can do this about it now."

Mr. Baldridge: I think one additional statement should have been made by the subcommittee regarding the advantages; namely, the increased safety to the men in getting to and from work by motor truck, rather than by motor car. I think that is an important addition which should belong in this report.

President Bond (presiding): Would you have anything to say regarding the remarks from the floor, that under present conditions, of course, we cannot expect to realize the advantages which you have outlined?

Mr. Baldridge: We hope the present conditions are temporary, and we expect to make them that way through our government and the boys at the front and through us people who must back them up and do our part.

Chairman O'Rourke: I would like to say to Mr. Clarke that, as chairman of the committee, in reviewing this subcommittee report, I did think something might have been said concerning the present emergency; but the very thing you mentioned, the change from day to day, caused me to hesitate to add anything to the report other than as presented.

The next subcommittee report we would like to offer is that on: Labor economies resulting from periodic spot welding of rail ends as compared with less frequent out-of-face welding, to be presented by Mr. W. G. Powrie, chairman of the subcommittee.

(Mr. Powrie read the report on Assignment 8, omitting paragraphs 4 and 5.)

Chairman O'Rourke: The assignment on: Labor economies to be derived from keeping vegetation out of ballast, was handled by Mr. C. R. Wright, in whose absence I will ask Mr. E. J. Bayer, a member of the subcommittee, to present the report, please.

E. J. Bayer (New York Central): I would like to direct your attention to the statement appearing in the Manual on page 22–5 reading as follows: "In the track, the elimination of vegetation facilitates drainage, increases the life of ties, reduces the fouling of ballast and otherwise decreases the cost of track maintenance." This statement implies that money can be saved, and track labor items most directly affected by the presence of vegetation in the ballast are: Renewing of crossties, maintaining ballast and maintaining track drainage.

The committee, after study, has reached the following conclusion:

(Mr. Bayer read the conclusion on page 242.)

Chairman O'Rourke: That concludes the report of Committee 22.

President Bond: Committee 22 is excused with the thanks of the Association.

Discussion on Buildings

(For Report, see pp. 123–139.)

(President Bond presiding.)

Chairman L. H. Laffoley (Canadian Pacific): This year Committee 6 was assigned six subjects. Of this assignment, we have managed to make a report on three. On the first subject, which is perennial—Revision of Manual—we present a progress report, including certain recommendations.

I will call on Mr. Belden, chairman of this subcommittee, to present this report.

G. A. Belden (Central of Georgia): The revisions listed on page 124 have been made for the purpose of having the AREA specifications for roofing materials conform with ASTM specifications and refer to the ASTM serial designations instead of printing these specifications in detail as is done at present.

At the time the report was ready to submit to the printer, the ASTM had approved and adopted a specification for steep roofing pitch but had not yet assigned a number to this specification. Hence, this specification is referred to as the current ASTM specification for steep roofing pitch without any serial designation.

Two additional specifications for built-up roofing are submitted for inclusion in the Manual. These appear on pages 125 and 126. These are built-up roofings, Type A–3 and Type A–4 using tarred rag felt, steep roofing pitch and slag, for use on roof decks having slope greater than two inches per foot and not exceeding six inches per foot.

The committee therefore moves that the revisions listed on page 124 be adopted for publication in the Manual.

(The motion was seconded, put to a vote and carried.)

Mr. Belden: The committee also moves that the specifications for built-up roofings, Type A–3 and Type A–4 published on pages 125 and 126 be adopted for publication in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Laffoley: The report on the second assignment—Preparation of specifications for railway buildings. Under this heading various specifications in regard to building work are prepared from time to time. The assignment which preceded this was a steel specification as a result of which we were asked if we would prepare a specification on welded structural steel.

Mr. Judd, chairman of this subcommittee, will now report on this subject.

F. R. Judd (Illinois Central): As Mr. Laffoley stated, it was at the convention of 1940 that Committee 6 submitted the revised specifications for structural steel and iron. At that presentation, the question of providing a specification for welding was

brought up on the floor of the convention, to which the committee replied that, as the subject under discussion was only a revision of the present specifications in the Manual which did not provide for welding, the question of providing such specification would be handled and submitted at a later date.

In accordance with that promise, the committee has now prepared such a specification and is submitting it as information. The specification is published on pages 126 to 136, inclusive. At the time it was published, the attention of Committee 15, which had collaborated with us on the specifications for structural steel, was called to the publication of this welding specification as a matter of information. We requested that committee to give us any comments it had to make, and we received a letter from the chairman of Committee 15 stating: "I will endeavor to place this matter in the hands of the subcommittee with a view of giving Committee 6 any suggestions Committee 15 can make, possibly by early next fall."

This is the kind of collaboration that Committee 6 has always received from Committee 15, and we are hoping to get the same kind of collaboration from other committees.

This specification is submitted as information at this time.

A. R. Wilson (Pennsylvania): I would like to ask Mr. Judd if his committee, instead of making the specification complete, as now written, to which it has given considerable thought—had considered whether it would serve the purpose to supplement the riveted specifications with clauses that apply only to a welded structure, rather than repeating all the cross references.

Mr. Judd: The reason we have followed that is due to the fact that this practice has been followed on other parts of the building specifications. For instance, there are four specifications on chimneys, reinforced concrete and brick and steel and reinforced brick chimneys in the Manual, and in each case that was accepted by cross reference, by publishing such paragraphs as apply to the particular specification and cross referencing to the previous specification. There are other specifications in the Manual where this practice has been followed and, in order to be consistent, we are doing the same thing with this specification on welding.

Mr. Wilson: You might make a precedent of not following that system. You might get a special case in which it would be easier to handle. I am offering this merely as a suggestion to the committee.

Mr. Judd: Your suggestion was discussed in the committee, but we have followed the preceding practice with the idea of bringing out these questions.

Secretary Lacher: I think that Mr. Wilson's remarks were prompted by the report that I made to the Committee on Manual of the Board, in which I directed attention to the fact that the Manual is getting so large, that anything we can do to save space within reason, will be of benefit to the people who buy and use the Manual.

Chairman Laffoley: The report on Assignment 3—Railroad warehouse requirements for handling quick frozen products. In the absence of Mr. Christiansen, I am going to ask Mr. Neal Howard if he will present this subcommittee report.

N. D. Howard (Railway Age): The report of the committee on its assignment to determine the requirements of railroad warehouses for handling quick frozen products consists of a rather comprehensive discussion of all phases of the subject.

The report is submitted as information. In this report the committee first defines and describes quick frozen foods, discusses the purpose of the process, the methods employed and other considerations. It then traces the development and growth of the quick frozen industry, pointing out that it had its inception in 1924, that it has grown

rapidly since 1932, and that in 1938 the total distribution of quick frozen products was in excess of 250,000,000 lb.

Next the report discusses the location of warehouses for handling quick frozen foods and the various aspects of the problem of loading and unloading cars. It then takes up the subject of design, pointing out that the same type of construction specified for general cold storage plants may also be used for quick frozen products, provided the insulation is increased in thickness to insure constant temperatures of —5 deg. to —10 deg. F. for storage and around —30 deg. F. for freezing rooms.

The arrangement, number and size of the rooms and other facilities are also given consideration in the report. Problems encountered in the transportation and distribution of quick frozen products are also discussed, it being pointed out that the extensive shipment of such products by rail has raised the need for an extensive refrigerated warehouse storage system.

Reference is also made to the method of refrigeration employed in railroad cars and to the use of portable refrigerated containers for frozen foods. Method of stocking quick frozen foods in refrigerator rooms and the desirability of precooling refrigerator cars and of keeping the cars, the storage space and the products at a low temperature during loading are also reported upon.

The committee names two essential requirements for the protection of quick frozen products during transportation and distribution as follows:

1. The products must be maintained at a low temperature of about 0 deg. F.
2. Temperature fluctuations must be avoided so that the permissible temperature range for storage shall be maintained between 0 deg. F. to —5 deg. F.

The report is concluded with the following remarks:

(Mr. Howard then read the conclusion appearing on page 139.)

Chairman Laffoley: That concludes the assignments on which we have to report this year.

President Bond: Thank you for a very interesting report. Your committee is excused with the thanks of the meeting.

Discussion on Ties

(For Report, see pp. 399–403.)

(Vice-President Clarke presiding.)

Chairman John Foley (War Production Board): This report brings to your consideration only one recommendation for revision of the Manual. The rest of the items are submitted as information only.

The report on Assignment 2—Extent of adherence to specifications—will be presented by the vice-chairman of the committee, Mr. Simpson.

W. D. Simpson (Seaboard Air Line): The subcommittee on adherence to specifications has continued its established practice of inspecting ties owned by railroads, and our report this year covers our observations of 5 yards in which more than 2,000,000 ties were stored. All of these ties were purchased under and very satisfactorily met AREA specifications.

We were interested in noting, and think it important to call to your attention, the fact that three of the roads whose ties were observed obtained them from contiguous territories. Despite this generally competitive situation, none of them found it necessary to lower the quality of its inspection. This is another illustration of the fact that we do not have to depart from our standards to procure ties. The acceptance of sub-

standard ties does not increase the supply; lax inspection merely encourages careless production and results in lower quality as a whole.

The committee sees developing rapidly in some parts of the country a shortage of ties, and, therefore, much competition for them. This will be an invitation and temptation to accept ties that do not properly meet the specifications. This committee is firmly convinced that you can and should have your specifications adhered to, for we are convinced that the greatest ultimate economy in the use of ties is obtained by adhering to our standards and that the best interests of both the producer and the consumer are served by so doing.

This report is offered as information.

Vice-President Clarke: At the present time, when the securing of ties is becoming so extremely difficult and there is a tendency on the part of many to depart somewhat from standards, I venture to suggest that this assignment may be even more important in the future than it has been in the past.

Chairman Foley: There is no report on Assignment 3—Substitutes for wood ties—there being no development along that line during the year, and the committee not wishing to inflict on the railroads any statistical reports regarding the ties already in track.

The report on Assignment 4 has already been printed in the June–July Bulletin and is not repeated here. Those statistics will, of course, appear in the Proceedings.

On page 401 you will find the report on Assignment 6 which will be presented by the chairman of the subcommittee, Mr. Butler, leaving the report on Assignment 5 to the last.

R. E. Butler (Newburgh & South Shore): This subject was first assigned to your committee in March, 1939.

In approaching the subject, it was decided to suspend thinking of anti-splitting devices until we determined whether or not there should be any. Our first report was presented in 1940 and published in Vol. 41, page 654 of the Proceedings. In this report it was developed that splits are caused by shrinkage of the wood as a result of loss of moisture during the seasoning period, and that even, slow seasoning would reduce splitting. Because there is no practical method for the drying of the large number of ties involved, it has been found necessary to resort to some sort of metal device to control the splitting of ties.

During the three years 1939 to 1941 your committee, in its study of the splitting problem, visited 17 treating plants and inspected, in various stages of seasoning, 6,315,000 ties belonging to 20 railroads. Our report is a summary of our observations and of the answers to a questionnaire submitted to all roads represented on the committee. Nearly all the roads whose ties were inspected used some type of anti-splitting device. The size, shape, time of application, and number of irons applied vary, but the results obtained in most cases are regarded by the railroads using them as fully justifying their application.

The information at hand does not warrant a definite recommendation as to standard practice at this time, and, therefore, we request that the subject be continued.

Chairman Foley: The report on Assignment 5, which involves a recommendation for revision of the Manual will be presented by Mr. Campbell in the absence of Mr. Burton, who found it impossible to be here.

F. G. Campbell (Elgin, Joliet & Eastern): This report, recommending a change in the Manual, was presented for consideration one year ago. It is brief, and I will read it.

(Mr. Campbell read the report on Assignment 5, omitting the first two paragraphs.)

Mr. Campbell: I move the adoption of this change for the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Foley: That completes the committee's report.

Vice-President Clarke: The report is a short one but very important. Do not misjudge its importance by its length. The committee is excused with our thanks. (Applause)

Discussion on Wood Preservation

(For Report, see pp. 405–468.)

(President Bond presiding.)

Chairman H. R. Duncan (Chicago, Burlington & Quincy): Twelve subjects were assigned to Committee 17, and we are reporting on six of them. The subcommittees assigned subjects 7 to 12, inclusive, have made considerable progress in the study of their assignments during the past year but have no reports completed to present at this time.

Subject 1—Revision of Manual—will be reported on by Mr. Foley, chairman of the subcommittee.

(Vice-President Clarke presiding.)

John Foley (War Production Board): The material in the AREA Manual of Recommended Practice in reference to wood preservation has not been revised for quite a while. It is because that material is not up to date that it has been deemed necessary to revise it. You will find the reasons given on page 406 for each change that is recommended.

On page 407, under the heading "Wood Preserving Fundamentals", is the material now in the Manual as General Provisions. The older material is somewhat more extensive, but the new statement covers the same class of information.

In order to expedite procedure, it has been decided that the motions for the adoption of this material be made only with reference to the headings. So the committee moves the adoption of the material on pages 407 and 408, entitled Wood Preserving Fundamentals.

(The motion was seconded, put to a vote and carried.)

Mr. Foley: On pages 408, 409, 410 and 411, there are given specifications for treating processes, which are designed to bring the Manual up to date as to practices in vogue among railroads and others who give preservative treatment to wood. This material is arranged somewhat differently than it was, but it is in accordance with practice found satisfactory, after trial and error, by the American Wood-Preservers' Association.

On page 410 there is an omission between the paragraphs numbered 209 and 210. The paragraph numbered 212 should also be between paragraphs 209 and 210. The wording is exactly the same and that particular paragraph regarding the temperature of the preservative belongs in both salt treatments by empty-cell processes.

It is moved that the material entitled "Specifications for Treating Processes" be inserted in the Manual as recommended practice.

(The motion was seconded, put to a vote and carried.)

Mr. Foley: On page 412 there are given specifications for creosote-coal tar solutions which provide for the types generally used by railroads. Heretofore the Association has had a standard for only one solution, but in order to have what might be called legal backing for practices that are in vogue, four standards for solutions have been evolved, and they correspond with similar standards adopted as federal specifications and also adopted by the American Wood-Preservers' Association.

It is moved that the material on page 412, entitled "Specifications for Creosote-Coal Tar Solution be inserted in the Manual as recommended practice.

(The motion was seconded, put to a vote and carried.)

Mr. Foley: On Manual pages 17–65 to 67 there is material relating to operations that is not strictly wood preservation. In order to confine the recommendations under wood preservation to matter germane to that subject, the committee decided to eliminate all of the matter under Preparation and Handling of Wood Before and After Treatment and substitute the paragraphs on page 413 of the committee's report under the heading Wood Preserving Plant Practice.

The committee moves that the material headed Wood Preserving Plant Practice be inserted in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Duncan: Report on Subject 2—Service test records for treated ties—will be presented by Mr. Loom of the Northern Pacific, the chairman of that committee.

A. J. Loom (Northern Pacific): The table of tie renewals per mile maintained on various roads has been revised to include data for 1940.

Reports of special test tracks are submitted for the Burlington, the Milwaukee, the North Western and the Northern Pacific.

This report has been compiled for a good many years and is being continued as information.

Chairman Duncan: Subject 3—Destruction by marine organisms and possible ways of prevention. The chairman of this committee, Dr. Clapp, isn't present, and I have asked Dr. Buckman, a member of the committee to present this report.

S. J. Buckman (Central Laboratories): This report gives the results of tests of various preservatives and protective methods in the Panama Canal Zone, in the San Francisco Bay region, in Australia and also at a number of testing stations along the eastern seaboard. The report covers a large number of different preservatives that are being tested, a number of the newer preservatives and also rather extensive tests on older products such as creosote, creosote-coal tar and coal tar.

This report is submitted as information.

Chairman Duncan: Subject 4—Effect of preservative treatment by the use of creosote-petroleum, and zinc chloride and petroleum. This report will be presented by the chairman of the subcommittee, Mr. Hughes of the Santa Fe.

R. P. Hughes (Atchison, Topeka & Santa Fe): Since it first received its assignment, this subcommittee has concerned itself with the study of the performance records of ties treated with creosote and petroleum and with zinc chloride and petroleum.

It has now become apparent that this work overlaps that being done by Subcommittee 2 of Committee 17—Service Test Records of Treated Ties. Therefore, it has been decided by the Committee on Outline of Work that the work of this subcommittee shall be taken over by Subcommittee 2.

Subcommittee 4 has brought its work up to date, and you will find on pages 449 to 461 a summary of the reports which it has submitted since 1924. I call your attention to the last paragraph of this summary on page 461.

(Mr. Hughes read the last paragraph under assignment 4, on page 461.)

Chairman Duncan: Subject 5—Destruction by termites and possible ways of prevention. Dr. von Schrenk of this committee was with us yesterday, but it is impossible for him to be here to present the report. It is printed on pages 461 and 462 and speaks for itself. It is submitted as information.

Subject 6—Revision of specifications for the treatment of Douglas fir. Mr. Belcher, the chairman of this subcommittee, was not able to be with us. The report of this

committee is the result of considerable effort over a period of several years. I had hoped that Mr. Belcher would be here to present the report himself as it is work that has been accomplished under his leadership.

The committee recommends the specifications for inclusion in the Manual to supersede Specifications for the Preservative Treatment of Douglas Fir, pages 17–47 to 17–55, and Specifications for the Treatment of Air-Seasoned Douglas Fir on pages 17–57 to 17–62 in the Manual.

I move for the adoption of the specification as presented.

(The motion was seconded, put to a vote and carried.)

Chairman Duncan: That completes the report of Committee 17.

Vice-President Clarke: You and your committee are doing a work of great importance to the railroad industry. An excellent report has been presented. We thank you for it, and the committee is excused with our appreciation. (Applause)

Discussion on Records and Accounts

(For Report, see pp. 379–397.)

(Vice-President Clarke presiding.)

Chairman C. A. Knowles (Chesapeake & Ohio): During the past year there have been many important developments pertaining to subjects assigned to your Committee on Records and Accounts.

I believe you will find them comprehensively dealt with in the committee's report and they will be summarized in some detail by the chairmen of the various subcommittees. As an introduction, I would like to call your attention to one or two of the more outstanding developments, among which are (1) the proposed order of the Interstate Commerce Commission to become effective January 1, 1943, making depreciation accounting mandatory for road property instead of permissive as has been the practice since the accounting classifications were prescribed, it being generally considered that this new accounting will have quite an effect upon maintenance budgets and the statements of net railway operating income of railroads; (2) many modifications of the accounting classifications recently made effective which, to some extent, have resulted in complicating comparisons of current operations with those of past years. Another development arises from reorganization proceedings.

These things I have spoken of are, on their face, accounting matters, and yet I believe that railway officers, other than accountants, engineering officers, officers in charge of construction and maintenance, will find that these changes in the accounting regulations are not without effect upon the conduct of the work for which they are responsible.

On page 381, there is a list of books, pamphlets and periodicals dealing with the subjects assigned to this committee. If you have not already done so, may I recommend the list for your extra-curricular study and reading.

The effects of this world-war will be far-reaching indeed. Not only does it cause a scarcity of materials needed in the construction, maintenance and operation of the railroad, but it even invades the realm of railroad accounting as witness the changes in accounting classifications to provide for the amortization of the costs of war defense facilities. Modern war is conducted on a fast tempo. Time is the most precious thing we have. Therefore, I think it behooves us to study our own situation and to discard those records which we have found or can find to be outmoded and to retain only those which are essential.

The report on Assignment 1—Revision of Manual—will be given by Mr. D. E. Field, chairman of the subcommittee.

D. E. Field (Columbus & Greenville): In line with suggestions made in last year's report, your subcommittee has made a complete rearrangement of Chapter 11 in the Manual. This proved to be even more difficult than a complicated jig-saw puzzle, but it is hoped that the Association's Committee on Publications will see fit to authorize the printing in due course. We of this subcommittee believe that the present cost will be more than offset in the future, as provision has been made for further changes and expansion without unduly upsetting the present subjects and their arrangement.

Chairman Knowles: The report on Assignment 2—Bibliography on subjects pertaining to records and accounts—will be given by Mr. Braden, chairman of the subcommittee.

E. V. Braden (Pittsburgh, Chartiers & Youghiogheny): Compiling a bibliography would be a drab, continuing duty if it were not for the game-like incentive to find articles strictly pertaining to records and accounts which offer a very special interest or information to some member or group of members of this Association, or even to those outside the Association who have learned to look to these reports and recommended practice for dependable guidance.

Outstanding in our list last year was a series of articles on railroad reorganizations A study of these revealed probably far-reaching developments; as expected, from the many reorganization proceedings during this year have come important rulings and decisions. Some of the important developments cited by Mr. Knowles are considered to have arisen from this source, and these, in turn, have brought about new regulations pertaining to records and accounts.

Each railroad, regardless of its involvement in reorganization, or otherwise, is now affected by the reclassification of ICC accounts and will be further affected by the depreciation of roadway property, to be effective January 1, 1943. Therefore the articles listed on these subjects in this year's bibliography should be of widest current interest.

Chairman Knowles: Report on Assignment 3—Office and drafting room practices—will be given by Mr. A. T. Powell.

A. T. Powell (Grand Trunk Western): This subject has been on the committee's docket for a number of years. Individual topics are assigned each year for study and report. Sometimes a finding seems definite and important enough to recommend for inclusion in the Manual. Others turn out to be more or less inclusive in nature and are submitted as information.

The topics assigned for this year are: (a) Drafting equipment and tools; (b) Specifications of materials to be used for drawings and draftings; (c) Standard system for filing drawings.

In the report on topic (a), recent developments in drafting room technique are discussed, such as:

1. The use of fluorescent lighting in drafting room work;
2. Float lettering;
3. Drawing projectors, and
4. Microphotographic cameras for office use.

This last subject deserves study where storage space is limited, inasmuch as photographic copies require only a small fractional part of the storage space which would be required if the original records were filed. In the Bureau of Census at Washington, records occupying 7,000 sq. ft. have been reduced by microphotography to 12

filing cabinets occupying 50 sq. ft., making a reduction in storage space of over 99 percent.

All of this material is offered as information.

The report on topic (b) embraces conclusions developed from previous studies of this subject.

(Mr. Powell then read the conclusions appearing on page 387 under item (b).)

Mr. Powell: Your committee recommends, and I move that the conclusions just quoted be published in the Manual.

(The motion was seconded, put to a vote and carried. Mr. Powell then read the report appearing under (c) on page 387.)

Chairman Knowles: The report on Assignment 4—Recommended practice to be followed with respect to maintenance of way accounts and statistical requirements—will be given by Mr. H. L. Restall, chairman of the subcommittee.

H. L. Restall (Boston & Maine): The subcommittee offers as information a recommended system for recording the characteristics and location of electrical equipment. Our studies with respect to records for maintenance of way accounts and their statistical requirements now, more than ever, have brought us most definitely to the conclusion that we should closely scrutinize our reports and ascertain if they are the right kind of records.

During this emergency we are going to be faced with a lack of man power to keep many of our records. Therefore, simple reports must be substituted and made to serve dual purposes, and such reports as exist, which cannot show themselves to be absolutely necessary should be temporarily suspended and some, we believe, permanently abolished.

Our machinery and tools are now being subjected to varying uses and double duty, and new machinery is difficult to obtain. Thus constant vigilance is demanded to get the greatest utility from what we have on hand. Here, again, is a call for the right kind of recording in such form as to best serve those upon whom the responsibility rests for the use and maintenance of these machines and tools.

We have a subcommittee under Records and Accounts whose assignment deals with methods of avoiding duplication, and simplification of reports as required by regulatory bodies. But before we venture too far away from home, are we sure that our own records are above reproach? Are they necessary? Are they simple to handle? Is there duplication? Do they give the proper control? In short, are they the right kind of records?

This subcommittee is going to devote a part of the coming year to making sure that our own house is in order. We feel it is a patriotic necessity.

Chairman Knowles: Your committee has no report to offer at this time upon Assignment 5—Construction reports and records. We have made some progress, but we are not in position to make a report at this time.

The report on Assignment 6—Valuation—will be given by Mr. S. H. Barnhart, chairman of the subcommittee.

S. H. Barnhart (Norfolk & Western): Federal valuation of railroads has now been with us for a period of more than 25 years. In the early days most railroad people felt that the task was so enormous and the cost so great, and as it was then thought there was no use that could or would be made of the results, that the effort was a useless burden upon the carriers. But as we now look back upon the progress that has been made throughout the past quarter of the century, we find that this work has been dovetailed into regular railroad routine, records required for valuation purposes having in many instances no doubt been substituted for other and probably, or possibly, more inefficient records. Methods and procedure of the Interstate Commerce Commission and

its bureaus have been so developed and are now so standardized that there no longer remains much question as to how valuations and elements of value announced by the Commission or its Bureau of Valuation are determined, at least within reasonably close margins. Present general routine work of railroads in connection with federal valuation is mostly confined to reporting of additions, betterments and retirements as required by the Commission's Valuation Order No. 3.

Much usage of valuation figures is now being made, for seldom is there a case of any importance before the Commission regarding rates, reorganization, refinancing, issuance of new securities, etc., but that valuation figures are introduced and, of course, it must be assumed that they are considered by the Commission in some manner in reaching decisions. To some this may be of little consequence; to others it may give concern. Possibly it would be well for the railroads to give more serious consideration to the introduction of valuation figures in such cases, where weight or consequence, which some may now think is of little moment, may be added by the mere establishment of such a precedent.

In the report on the first assignment—Résumé of developments of the current year in connection with regulatory bodies and the courts, the first part deals with developments during the year. There are several things to which attention should be invited: First, the report of the very definite fixing by the Commission of the time for reporting the annual changes in property. The result of this order is that by December 31, 1942 all arrearages in the returns of changes in property must be made up and thereafter these returns must be made by December 31 following the year in which the changes occur. It is probable the Commission will insist upon this program.

Reference to usage of values or elements of value ascertained by either the Commission or the Bureau of Valuation is made in this section of the subcommittee's report.

The second section of Assignment 6 (a), that is, court decisions in connection with the valuation subject, contains reference to and comments upon several decisions in court cases. These decisions in court cases with respect to valuation may have been turned aside a bit in your mind with the decision of the Supreme Court on Monday last in the case of the Natural Gas Pipe Line Company and the Texoma Natural Gas Company. We don't have the real facts in connection with that decision except as given in press dispatches, but it seems that the theory of cost of reproduction (while we don't want to agree that it has been completely knocked out) may have received a very decided and definite blow. The committee proposes to make a final report on that case in its report next year.

Assignment 6 (b) deals with Interstate Commerce Commission valuation orders, reports and records. The report records the decision of the Commission with respect to the manner in which the reports for joint governmental-railroad projects shall be reported insofar as overhead highway crossings are concerned, but the matter of form of similar reports of undergrade crossing changes has not as yet been decided..

Chairman Knowles: The report on Assignment 7—Report upon changes in, revisions and interpretations of, ICC accounting classifications—will be given by Mr. H. D. Barnes, chairman of the subcommittee.

H. D. Barnes (Chicago & North Western): In presenting a brief report for this subcommittee, I stated that it was obvious that the accounting classifications were undergoing a gradual revision. The changes made or proposed during the past year indicate that this revision is anything but gradual. The effects of some of these revisions are far-reaching and have a direct effect upon those responsible for the maintenance of railways. These changes are so numerous, it is difficult to keep them all in mind. In

preparing this report, we have attempted to furnish a brief index of the transactions of the years, that are of interest to engineers.

The first part of the report contains a list of proposed accounting case rulings or orders submitted to Mr. Bunnell, vice-president of the Association of American Railroads by the Bureau of Accounts of the Interstate Commerce Commission, which have been reviewed by your committee. This is followed by a list of the orders modifying the accounting classifications and accounting rulings or interpretations issued by the Interstate Commerce Commission during the year.

Since this report was prepared, the Commission has issued an order dated January 19 this year, effective January 1, 1942, of particular interest to our members. This order substitutes the group method for the unit method of depreciation accounting as the optional method of depreciation accounting for certain roadway property.

It is expected that a mandatory order for depreciation accounting for roadway property will be released shortly.

Chairman Knowles: This concludes the report of Committee 11.

Vice-President Clarke: You have heard the report. Certainly, it has been presented in a very interesting way. I am sure we have taken note of what Mr. Knowles said in regard to the importance of accounting to the engineering officers. Willingly or unwillingly, we are being forced to recognize that. You have also noted that the committee, in the report, has taken note of the present emergency conditions, and it has presented to us a report on records and accounts which even an engineering officer finds interesting and can understand.

The committee is excused with the thanks of the Association.

Discussion on Rail

(For Report, see pp. 573–640.)

(President Bond presiding.)

Chairman W. H. Penfield (Chicago, Milwaukee, St. Paul & Pacific): During the year the committee lost three members, G. R. Smiley who died June 10, W. J. Backes who died January 4, and L. H. Bond who died February 27. These members were active in committee work, and their loss will be keenly felt by the other members.

Ten subjects were assigned to the committee for study and investigation during the year, and progress reports are submitted to cover the subcommittee activities.

Under Revision of Manual we are recommending two changes, a revision of certain items in the rail specifications and also a revision and addition to definitions shown in the glossary. Mr. C. B. Bronson, vice-chairman of Committee 4 will present our recommendations for revision of the Manual.

C. B. Bronson (New York Central): In the first item—Revision of Rail Specifications—the changes involved are, elimination of Brinnel hardness test, which has been a matter of information and is no longer necessary, and the second item, Section 406, permission to cut rail back to sound metal. Both of these changes have been under consideration with the manufacturers. I move the adoption of these two revisions of the rail specification.

(The motion was seconded, put to a vote and carried.)

Mr. Bronson: To clarify the identity of certain types of defects it was deemed advisable to make revisions of and additions to the definitions appearing in the instructions that go along with Forms 402–C and 402–E.

I would like to make a motion that the definitions as shown in the Bulletin be substituted for those now in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Penfield: Assignment 2 reads as follows: Further research, including details of mill practice and manufacture as they affect rail quality and rail failures, giving special attention to transverse fissure failures and other defects in the head, web and base, collaborating with Rail Manufacturers' Technical Committee. Also, Specifications for thermal treatment of rail, such as control cooled, Brunorized, etc. The eighth progress report of the joint investigation of fissures in rails appears on pages 607–640. After the other subcommittee reports have been presented, Mr. H. F. Moore, research professor of engineering materials at the University of Illinois, who has been in charge of this investigation since its inception in 1931, will give an oral discussion of the report, bringing out some of the highlights and the activities now under way.

On page 617 is shown a recommended practice for control cooling of railroad rails. Paragraph 6 of the recommended practice provides that the containers shall be so insulated that none of the rails in the container shall drop below a temperature of 300 deg. F. in 7 hours from the time that the bottom tier is placed in the container.

The mills have made excellent progress and necessary changes in their containers to comply with this paragraph. However, until such time as they can meet this requirement in all instances, it is recommended that, if the temperature of the controlled rail in the bottom layer does fall slightly below 300 deg. F. in 7 hours, the covers will not be removed until the temperature in the mid-section of pile of rail in the containers has reached 300 deg. F., as provided in paragraph 7 of the tentative specifications for the controlled cooling of rail which was published in the Proceedings for 1937, Vol. 38, on page 644. This has been the recommended practice under which controlled cooling was done prior to the spring of 1941.

Assignment 3 reads: Compilation of statistics, (a) All rail failures, making special study of transverse fissure failures; (b) Compilation of statistics for determining the performance of control-cooled and Brunorized rail in service with respect to rail failures, with the view toward evaluating the higher price paid for treated than for untreated rails. Mr. W. C. Barnes, engineer of tests of the Rail Committee, is the subcommittee chairman and will read the report.

W. C. Barnes (American Railway Engineering Association): The rail failures are prepared in the usual manner. The statistics this year cover tonnages exceeding those reported last year by approximately 113,000 tons. Attention is called to Table I which shows that the 1935 rollings, with the five-year period of observations now concluded, show a failure rate of 51 service-plus-detected failures of all types per 100 track miles, which is somewhat higher than the low record of 35.8 established by the 1934 rollings, but is still lower than the figures established by the rollings of all other preceding years, of which we have record. This is clearly shown in Fig. 1. The remainder of the report requires no special comment. The statistics are submitted as information.

Transverse fissure statistics—Table 1 shows separately, by roads, the service and detected fissure failures which have occurred during each of the last 10 years, as reported in all rollings, no matter how old. It will be noted that there was a considerable increase in detected failures in 1940 over those in 1939.

Fortunately, there was also a decrease in the service failures in 1940 as compared to 1939 in substantially an equal amount. This is shown graphically in Fig. 1. Examination of Figs. 2 and 3, which depict fissure failure rates from the date rolled to December 31, 1940, by mills, shows that the failure rates in the more recent rollings have been greatly improved compared with those recorded for the rollings of '31 to '33. Some of this improvement is no doubt due to the increased use of control-cooled and Brunorized rail.

These statistics are submitted as information.

Data are also being accumulated to assist in determining the performance of controlled-cooled and Brunorized rail in track. Table 1 shows the tonnages of controlled-cooled and Brunorized contract rail purchased to June 30, 1941, segregated by roads, based on reports submitted by roads represented on the Rail Committee. The total tons of controlled-cooled rail reported by all the roads, is shown as 3,863,372 tons, and of Brunorized rail 140,251, making a grand total of 4,003,623, an increase over the total tonnage reported to June 30, 1940, of 857,544 tons. The accumulated failures to November 17, 1941, the date this report was completed, are shown, classified as to type, in Table 2. Your attention is called to the explanation of the small number of so-called fissure failures in the footnotes to Table 2 and in the text.

Additional information obtained since this table was printed indicates that the transverse fissure listed as occurring in Tennessee rail was incorrectly reported by the road and that it should have been ascribed to some other mill whose identity is not yet fully determined.

In next year's report I will list separately the detailed factors which are now included under the general heading of transverse fissures, to agree with the new classification of failures which was recommended today in our report on revision of Manual, which you approved.

This report is submitted as information.

Chairman Penfield: Assignment 4—Cause and prevention of rail battering and methods of reconditioning rail ends. Mr. F. M. Graham, chairman of this subcommittee, has resigned from active work on the Rail Committee. The report will be presented by Mr. C. J. Geyer, who is now the chairman of subcommittee 4.

C. J. Geyer (Chesapeake & Ohio): The work of this subcommittee consists of two tests, which have been described in previous bulletins. Only time and traffic will enable us to draw conclusions as a result of those tests, and that time and traffic have not yet been reached. The tests so far have developed nothing of any consequence that we could report here. You members can follow the details of the two field tests from previous reports and in others that will be made from time to time as the tests progress.

This is submitted as information.

Chairman Penfield: Assignment 5—Economic value of different sizes of rail. Mr. J. M. Farrin, special engineer, Illinois Central Railroad, is the subcommittee chairman and will make the report.

J. M. Farrin (Illinois Central): During the past year the report previously prepared was entirely rewritten and that part dealing with the effect of the different sizes of rail has been greatly altered and ratios appreciably changed. Due to this change and also to the fact that it was thought best that the report as a whole should be studied further before presentation, it was decided not to present a completed report for this year. The subject is therefore reported for progress only, with the recommendation that it be continued for the coming year.

Chairman Penfield: Assignment 6—Continuous welding of rail, collaborating with Committee 5—Track. Mr. J. C. Patterson, subcommittee chairman, will make the report.

J. C. Patterson (Erie): This is a summary, bringing up to date the service record of the various continuous welded rail installations. We report additional service failures of continuous welded rail on 6 of the installations listed in the report published in the Proceedings for 1941, Vol. 42, pages 660 and 662.

(He then reviewed the data in the table on page 592 of this volume.)

Mr. Patterson: This report is submitted as information.

Chairman Penfield: Assignment 7—Service tests of various types of joint bars. Mr. Ray McBrian is the subcommittee chairman on Assignment 7. He is also subcommittee chairman on Assignment 8 which reads: Investigate joint bar failures and give consideration to the revision of design and specifications. He will make the report on both of these assignments.

Ray McBrian (Denver & Rio Grande Western): The report of the subcommittee on—Service tests of various types of joint bars is a progress report and covers observations and measurements made in 1941 on stretches of the Atchison, Topeka & Santa Fe. The principal measurements were: Joint camber on rail head; rail surface profile; out-to-out distance of bars; bolt tension on the Santa Fe.

In the conclusions on page 601, comments are given as to the current trends and conditions. These will undoubtedly continue to develop to a point that will permit more definite conclusions to be drawn.

It will be noted in the conclusions that the end-hardened rails on both test tracks in the four-year period have shown improved resistance to rail-end batter, only a small amount of wear having been developed. It will be noted also that the Evertite bars on the Pennsylvania were removed.

The report is offered as information, with the recommendation that the subject be continued.

The report on Assignment 8—Investigate joint bar failures and give consideration to the revision of design and specifications—is a progress report and outlines tests to be made on the rolling-load machine at the University of Illinois, these tests having been started this year. These tests cover the effect of "cocked" position of bars; the effect of the design of bars; the effect of bolt tension on rail-end breakage, and the determination of the fatigue strength of joint bars.

The report also refers to the observational measurements on a special lot of joint bars on the Burlington during the past year. The report is offered as information, with the recommendation that the subject be continued.

Chairman Penfield: Assignment 9—Corrugated rail-causes and remedy; effect upon riding qualities of tracks and upon the costs of track and equipment maintenance. Mr. Maro Johnson is the subcommittee chairman and will present the report.

Maro Johnson (Illinois Central): This is a progress report. It has been found that the subject is a rather elusive one. So far, the report as presented consists principally of a brief review of an investigation made by the American Transit Association on the corrugation of street car rails. The conclusion of this Association so far as corrugation on rails of that kind is concerned is that the primary cause is overloading of the rail surface, and that the resulting flow of the surface metal, rather than abrasive wear, is the chief element in the formation of corrugations, this progressive flow being caused by synchronous wheel pounding added to the aggregate of those stresses which the rail is called on to bear.

The report is presented as information.

Chairman Penfield: Assignment 10—Development and characteristics of fractures under engine burns in rail, together with investigation as to the effectiveness of welding up engine burns by oxy-acetylene or electric methods. Mr. J. B. Akers is the subcommittee chairman and will make the report.

J. B. Akers (Southern): The report on this subject is preliminary and for information only.

(He read the report on Assignment 10, omitting the last two paragraphs.)

Mr. Akers: This subject of engine burns and fractures and some method of curing or attempting to cure them, is one that bothers a great many railroads. On my own

railroad it has assumed serious proportions. We know that engine burn fractures are not brought about by the quality of the steel but by train handling. We must, if we can, develop some method to obviate them. If we cannot do it through education of the locomotive enginemen, then some method of building up, or possibly directing the removal of the rail, may be necessary. Thousands of burned rails have been built up, and trouble with rails so built up, according to the reports that we have at this time, is quite limited.

The size of an engine burn is no index apparently, as to whether or not fractures will occur. We have many samples of what any of us would term as very minor burns, yet they have developed into some of the worst fractures. We see no connection so far between minor burns or heavy burns. The desire to build them up is brought about, of course, by the necessity for saving steel and to prevent, if we can, some of the difficulties of the maintenance forces, because it is well known that, if you have a badly burned rail, you will have a terrific pound that will cause irregularity in track surface.

We ask all members to bear us in mind on this subject and give us all of the information they can. If you are building up joints, please notify us through the secretary, Mr. Lacher.

This is presented as information only.

Chairman Penfield: That ends our assignments and, with your permission, we will turn the meeting over to Professor Moore.

(H. F. Moore, University of Illinois, gave the eighth progress report of the joint investigation of fissures in railroad rails, illustrated by slides, page 607.)

President Bond: We want to thank the Rail Committee for a very excellent report, and Professor Moore for a very enlightening discussion. (Applause)

Discussion on Uniform General Contract Forms

(For Report, see pp. 107–121.)

(President Bond presiding.)

Chairman W. G. Nusz (Illinois Central): The subcommittee on Revision of Manual made a thorough study of the Manual, and we have no changes to offer, but it was called to our attention that one of the contracts now included in the Manual, due to changed conditions, should probably be revised. This work being of unusual size, it was assigned to a special committee of which Mr. W. R. Swatosh is chairman, and he will present the report of the subcommittee.

W. R. Swatosh (Erie): At the request of the Electrical Section, Engineering Division, AAR, this subcommittee has been collaborating with Committee 1—Power Supply of that Section, in a revision of the Form of Agreement for the Purchase of Electrical Energy for Other Than Traction Purposes. A form is submitted herewith which, if later adopted, will replace the form now in the Manual. This form is submitted as information and will be studied next year.

The committee would like to make a minor revision in paragraph (f) of Article 6—Rates. After the words "generating station" in the first sentence of that paragraph, we would like to add the two words "or stations."

The committee will be pleased to have comments from the members of the Association on this agreement.

Chairman Nusz: The second assignment to the committee was: Suggestions for use in preparing a lease for air right development. The report will be presented by Mr. J. S. Lillie, chairman of the subcommittee.

J. S. Lillie (Grand Trunk Western): The report of this committee is submitted as information, with the recommendation that it be not included in the Manual. It is a final report on the subject, and the committee recommends that it be dropped.

Several years ago Committee 20 prepared a form, now in the Manual covering conveyance of title for air right development, and the present assignment grew out of the former subject. After canvassing the matter thoroughly, your committee feels that it is impossible to make a uniform general contract which would meet all conditions all over the United States. We are therefore submitting this report as being of some value to a man who has to attack the subject.

Its principal value, I believe, is a list of the leases and documents available for study in the preparation of such a form, shown on page 114.

Chairman Nusz: The third subject assigned to the committee was: Form of agreement for wire or cable line crossings, collaborating with Committee 3—Overhead Transmission Line and Catenary Construction, Electrical Section, Engineering Division, AAR. The report will be presented by Mr. F. L. Nicholson, chairman of the subcommittee.

F. L. Nicholson (Norfolk Southern): During the 1940 convention Committee 20 presented, for such action as the convention desired to take, a form of agreement that had been prepared by a special committee of the Engineering Division, AAR, at the request of the Rural Electrification Administration. The assignment was "to prepare a uniform contract and specifications governing wire crossings as a basis of meeting the requirements of the Rural Electrification Administration which will be satisfactory to the railroads generally."

This assignment was made November 11, 1938 and diligently worked on until October, 1939 when the tentative report was filed for the 1940 convention. It was then stated that the form was not complete as it had not been approved either by the Rural Electrification Administration or by the Association of American Railroads, but because of the general interest and the number of inquiries as to progress, it was thought wise to adopt it as recommended practice for such use as the members desired to make of it.

The committee continued its negotiations with the REA committee in an effort to reconcile the differences in viewpoint then prevailing, believing that a form of agreement reasonably satisfactory to both parties would be very advantageous.

These discussions have resulted in certain changes in the form as presented, which we believe better protect the interests of both parties, and it now meets with the approval of the Special Committee, the General Committee of the Engineering Division, AAR, Committee 20 of the AREA, and is acceptable to the Rural Electrification Administration. This form has also been approved by letter ballot of the member roads of the AAR as recommended practice.

Slight changes have been made in the data sheet, Exhibit "A" which is intended as an application form, showing minimum information requirements to enable the railway to accept or reject the proposal when submitted by the applicant, the railway may require additional information before approval, if so minded. This form is not intended to be a specification as referred to in the assignment. The specifications for wire crossings referred to in the assignment are being prepared by a committee of electrical representatives of the Special Committee and, when completed, will probably be printed in the Manual of the Electrical Section, Engineering Division. Reference to the specifications to be used is in Section 2 of the agreement.

The Form of Agreement and Exhibit "A", Application Data, are now completed and, as I have already recited, have been approved by these various committees and

bodies and has been recommended to the member roads of the AAR as recommended practice. It is presented to you now for inclusion in the Manual and I so move.

(The motion was seconded, put to a vote and carried.)

Mr. Nicholson: The Form of Agreement for Wire or Cable Line Crossings, together with Exhibit "A" adopted in 1940, and now in the Manual, on pages 20–112.1 through 112.5, is in minor respects in conflict with this form just adopted. I move that that form be withdrawn from the Manual.

(The motion was seconded, put to a vote and carried.)

Mr. Nicholson: The Form of Agreement for Wire Line Crossings adopted in 1936, and in the Manual, page 20–113 through 115, which was used as a basis for this new form now submitted is also in conflict in some respects therewith. We move the withdrawal of that form from the Manual.

(The motion was seconded, put to a vote and carried.)

Mr. Nicholson: There is now in the Manual a form bearing the title "Form of License for Wires, Pipes, Conduits, Drains, Hopper Pits, and Other Structures on Railway Property". We move the deletion of the word "Wire" from the title of this form.

(The motion was seconded, put to a vote and carried.)

Chairman Nusz: The fourth assignment to the committee was: Form of agreement for advertising signs on railways, including signs in coaches. The committee has done considerable work on this and collected a lot of data but is not ready to report on it at the present time. This concludes the report of Committee 20.

President Bond: We are very much obliged to Mr. Nusz and his very able committee for their presentations. The committee is therefore excused with the thanks of the Association.

Discussion on Waterproofing of Railway Structures

(For Report, see pp. 357–359.)

(Vice-President Clark presiding.)

Chairman J. A. Lahmer (Missouri Pacific): The first part of the report consists of some minor revisions of Manual matter. The first one has reference to the treating of cotton fabric with the bitumen. What we are doing is to recommend that the clause covering that process shall be changed to read: "This shall be accomplished by spraying the fabric with the saturant or by passing the fabric through the saturant, and then calendering it in the presence of heat."

The change consists of the addition of the words "spraying the fabric with saturant." We find that that is a process that has been in use for some little time and has given satisfactory results, and are merely bringing the specifications up to date.

I move that this change be adopted and included in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Lahmer: The next change has reference to the untreated fabric. As the specifications now stand, we have two clauses, one five-ounce and the other for four-ounce fabric, each with its own thread count. As announced last year, we had been informed by several of the producers of treated fabric that they could no longer get the five-ounce cloth. We are therefore recommending the following changes, which simply amount to eliminating the characteristics of five-ounce cloth. We shall still have in our Manual the specifications for the four-ounce cloth which is now being furnished, according to the manufacturers. The changes proposed are in Section 208: (He read the changes in (a), (b), and (c).

Chairman Lahmer: In (f), which relates to the measurement of the elongation without fracture, we have offered a modification to take notice of the more up-to-date method of measuring this elongation than was in use at the time the specification was originally adopted. The changed part will read: "When measured by rule or scale, not less than 10 percent; when measured by autographic recording device, not less than 8 percent."

The findings of the laboratories that have used these is that the autographic recording device detects the fracture a little bit sooner, and therefore we have a lower dip.

There is one more change with reference to the cloth, and that is simply a matter of information. The old specification reads: "The pliability at 32° F. shall be 10." The "10" refers to the description of the particular test which is embodied in the ASTM tests. What we are doing now is simply to supply the description of what that 10 is, which is as follows: "Shall not crack when bent over a 1/16-inch mandrel through an arc of 180° in one direction and then through 360° over the same mandrel in the opposite direction."

I move these changes be adopted and incorporated in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Lahmer: The next portion of the report relates to some comparative tests of waterproofing asphalts and coal tar pitches, in which we have undertaken to ascertain the relative merits of these two kinds of material.

I will ask Mr. Robinson, the chairman of the subcommittee, to present this report.

G. E. Robinson (Cleveland, Cincinnati, Chicago & St. Louis): This report is a progress report and is very short.

(He read the report on Assignment 2, with the exception of the last sentence.)

Mr. Robinson: The first series of tests is practically complete at the present time. The remainder of the tests will be completed later in the year.

This is presented as information.

Chairman Lahmer: The remainder of the report consists of a statement of progress in the study of ASTM specifications for waterproofing materials and requires no action. Both the ASTM and your committee are working on the differences between our specifications, and we appear to be making some progress.

That concludes the report.

Vice-President Clarke: If there are no remarks or discussion, the committee is excused with our thanks. (Applause)

Discussion on Clearances

(Oral Report.)

(Vice-President Clarke presiding.)

Chairman A. R. Wilson (Pennsylvania): As indicated in the program, a brief report is to be made at this time on the activity of your committee.

The Car Construction Committee of the Mechanical Division is preparing a design for AAR standard box car. This box car will be large enough to meet the demands of the shippers, and at the same time must be small enough in external dimensions to be handled over the railways. The Mechanical Division have submitted an outline of such a car to your committee.

During the past year the Clearance Committee has been studying information received from all the railroads, pertaining to their restricted clearance points, with the

view to approving or disapproving the outline submitted by the Car Construction Committee so that if such a car is built, it will have maximum use in interchange between the various railroads.

This work is about completed, and a report should be made early this year. Basically, equipment diagrams give this committee information from which other diagrams can be presented and approved. Such diagrams were presented to the Association two years ago and withdrawn pending studies which are now being made.

Vice-President Clarke: Thank you very much for your report, Mr. Wilson. (Applause)

Discussion on Yards and Terminals

(For Report, see pp. 141–166.)

(President Bond presiding.)

Chairman C. H. Mottier (Illinois Central): This year our committee was given eight assignments and we report on six, although the revision of the Manual is not set forth in a separate report but is covered in the report on Assignment 2 which will now be presented by the subcommittee chairman, Mr. Hedley.

W. J. Hedley (Wabash): The report of subcommittee 2 is on Terminal facilities required for servicing electrical and air conditioning equipment in passenger cars.

This year's report is a continuation of a report which was otherwise completed last year, and this report contains the recommendations for changes and additions for publication in the Manual. Those changes and additions are as follows:

(Mr. Hedley then read the material appearing under the heading "Passenger Terminals" on pages 142 and 143.)

Mr. Hedley: I move the adoption of these additions and changes for publication in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Mottier: Assignment 3—Scales used in railway service. This will be reported on by Mr. Harrison, chairman of the subcommittee.

M. J. J. Harrison (Pennsylvania): A brief progress report appears on page 143. Your committee has no specific recommendation to make on the particular subject under consideration at this time, and the progress report is simply for the purpose of bringing formally to the attention of the Association and other interested persons the fact that the subject is under active consideration in the subcommittee.

Chairman Mottier: Assignment 4—Classification yards, collaborating with Committee 16—Economics of Railway Location and Operation. The report will be presented by Mr. Hand, chairman of the subcommittee.

G. F. Hand (New York, New Haven & Hartford): As you probably all know by this time, the classification yard subcommittee works from year to year on different features of the various operations in the yard. This year the committee has selected, under this general assignment, the subject of communication at hump classification yards and submits as information this report on the different methods of communication now in use, and their application in connection with the operations in the classification yard from the time trains enter the receiving yard until they depart from either the classification yard or the departure yard.

We have indicated and described different methods of communication, beginning at the top of page 144. You will find that 10 methods are described, following which

we have indicated how these different methods of communication may be used and are used in ordinary classification yard operations, as I said before, beginning at the reception of trains in the receiving yard and winding up with the dispatching of the trains.

This report is submitted as information.

Chairman Mottier: Assignment 7—Modernization of passenger terminals. This report will be presented by Mr. Ripley, chairman of the subcommittee.

H. L. Ripley (New York, New Haven & Hartford): When the matter of modernization of passenger terminals was given to this committee, it seemed like a timely subject, one that would be of interest to the railroads and to the public; and one that would point to a likely way of bringing back to the rails some of the business then badly needed but lost to other modes of travel. The war has changed that picture.

As it seems to me now, instead of wondering how we can contrive to keep alive under a falling volume of traffic vouchsafed to us, the wonder today is how we are going to handle the traffic that, literally, is being forced upon us. How are we going to find the means to equip ourselves to do the job that must be done by us, if it be done at all, to win the war, if it is to be won?

It will do no good to produce vast stocks of war equipment and vast numbers of trained fighters unless they can be delivered to the point where they are needed, when they are needed. The materials and supplies necessary to enable us to do our job are the same kinds of materials and supplies needed by our fighting men to do theirs and by industry to equip them to do it. So it is not likely that much of it should, or will, be diverted now to the making of our passenger terminals more attractive or even more convenient or better suited to their purpose.

Of course the present condition is but temporary, whatever the final outcome may be.

Nobody knows today what that outcome will be, nor what future living conditions will be. We do know, or should by this time, that it will take all we have and are, to reverse the field and overcome the handicap that has overtaken us while we were asleep; not years from now but now.

We must forget about any theoretical "business as usual", "the more abundant life", or so-called "standard of living"; they can't be had in war time. We must forget what we would like to have and to do and fix our mind and heart and will upon what we must do. Forget about employing bubble dancers to teach other dancers to teach our children to play hop-scotch; and forget, for the time being, among other things, the modernization of passenger terminals that have and can continue to serve their purpose, and concentrate our effort upon things that are vital, if we are to win through in the end; or so it seems to me.

When this subject was assigned to the committee and the first draft of the report was made, it did not seem as though the subject would lend itself to material for the Manual. As time went on and the matter had further consideration, some of the committee felt that certain of the highlights should be pointed out, things that other roads have found necessary or desirable to do. As a consequence, beginning on page 156 you will find Conclusions (Tentative). These are not submitted for inclusion in the Manual at this time.

Two parallel assignments were given by the Committee on Outline of Work to two separate committees, very much alike, Committee 6 and Committee 14.

Now, that being true, it is practically impossible for either committee to handle its job without overlap, if any report they made is going to say anything, because if

the committees avoid overlap, what is left would be—well, I would say—futile, if not absurd. Committee 14, so far as I know, started its work first. We have included in our report these tentative conclusions. We hope Committee 6 will give them consideration. We will be glad to cooperate.

The report is presented as information.

Chairman Mottier: Assignment 8, and our last—Bibliography on subjects pertaining to yards and terminals appearing in current periodicals. This report will be presented by Mr. Tratman, chairman of the subcommittee.

E. E. R. Tratman (Wheaton, Ill.): There is not very much to say about this report. A bibliography is a sort of reservoir of information, and its value depends upon the extent to which it is found useful. As to that, it is up to you more than to me.

There are two aspects of the subject which are not covered. The first is the constructive work that is being done in this country in the provision of trackage and terminals and yards for the great munition plants and the shipbuilding yards and the army camps and the storehouses. I believe that in some of these plants the classification yards are so extensive as to require complete yard organizations.

The other subject is the vast destructive work which is going on in Europe and all over the world, in the bombing and destruction of stations, terminals, yards, junctions, in order to interrupt the service of supplies.

After the war there will be and there must be a great reconstruction program, but the great problem, when that time comes, will be the financial problem. I think that is all that needs to be said about this bibliography.

Chairman Mottier: According to my watch we are about 23 min. ahead of schedule. We want to use a part of the 23 min. to acquaint you with the rather remarkable performance in which Mr. Tratman here has played a conspicuous part. Perhaps some of you took time to review the report of the secretary, Mr. Lacher. If you did, you noticed a short paragraph calling attention to the fact that Mr. Tratman has been a member of the Yards and Terminals Committee, since the organization of the Association. That is an outstanding record. As a matter of fact, the next nearest contestant is two years behind him. We think this is very worthy of mention on this occasion.

Yesterday I took occasion to review Volume 1 of the Proceedings, and I find that, as has been previously stated by others who have investigated the record, Mr. Tratman appears as a charter member. His number is 215. This morning Mr. Lacher handed me a file which contains Mr. Tratman's application for membership. I did not have that yesterday, so I took this Volume 1 and looked for the Yards and Terminals Committee, and I found that that first committee, appointed back in 1899 had 11 members. The chairman was Mr. Sullivan who was general superintendent of the Illinois Central in Chicago. I also noted Mr. Tratman's name on the list.

My curiosity got the better of me, and I took this list of 11 men and checked it back against our current Year Book to find how many of that original 11 are still active members of our Association. I find, Mr. Tratman, that there is one, and that is Mr. Tratman, another case, I presume, of the survival of the fittest.

Then to investigate this rather remarkable performance still further, I looked in Who's Who in America and Who's Who in Engineering to get some idea of Mr. Tratman's age. I found biographical sketches in both of those books but no clue to the secret.

Mr. Tratman, I have it here on this paper but I am not going to tell you how young Mr. Tratman is because that record did not appear in Who's Who in America or Who's Who in Engineering. But I will give you a little clue and maybe you can guess.

According to those biographical sketches, Mr. Tratman was born and educated in England, and he came to this country presumably fully educated in 1884. He was a rodman on the Long Island Railroad in '84, and in '85, according to these papers, and '86, according to Who's Who in America, he started to work for the Engineering News, and was employed by that publication for 46 years. Incidentally, I will refer to this original application. It says here that he joined the American Society of Civil Engineers in 1886, and in 1888 he was awarded the Norman Medal by the Society for a paper on "English Railway Track."

Incidentally, he has written many other books and articles and Who's Who gives a list of the various honors conferred on him. In '97, I think it was, Mr. Tratman came west to become Western Editor of the Engineering News. In that same year he wrote the book, "Tratman's Railway Track and Trackwork"—that big, thick, red book—I see some you nodding—that you studied in school 30, 35, 40 and maybe some of you 45 years ago.

We will just stop here and say a little bit about Mr. Tratman and his work on the Yards and Terminals Committee. He was vice-chairman for 8 years. If you look over the Proceedings, you will find that these 43 years on our committee have been active years. For example, every year since 1930, Mr. Tratman has made a report on bibliography.

For the benefit of some of you men who don't know Mr. Tratman, I want to say that—well, some of us still think that modesty is a virtue. Perhaps we don't practice it but those here at the table who know Mr. Tratman, know why I am inspired to make that statement, because Mr. Tratman is very modest; he is very quiet and unassuming, but tremendously dependable. Whenever we give Mr. Tratman a job, he always delivers. We have never known him to strike out.

Mr. Tratman, these are not idle words, when I say that those of us here on the platform, who have known you for many years, hold for you a very keen affection and a deep admiration for your many fine qualities, and we want to wish you many more years of active service on our committee, so that you will establish a record that will stand for all time, as we believe that you will.

(The audience arose and applauded.)

Mr. Tratman: Mr. Mottier's remarks remind me rather of Dickens' story of the Christmas Carol. You may remember that when the ghost of Jacob Marley, Mr. Scrooge's partner, comes to Mr. Scrooge and begins to tell him what a scoundrel he has been all his life, the rather frightened Mr. Scrooge says, "Don't be flowery, Jacob, please."

So I might say to Mr. Mottier, "Don't be flowery."

My recollection of this Association goes back, I suppose, to '98 or '99, when Mr. Torrey, then chief engineer with the Michigan Central, came to me with a list of engineers he was enlisting in what was to be this Association. He invited me to join and I accepted the invitation. I don't remember what committees I was on at first, but I think I have been on the Yards and Terminals Committee for at least some 40 years. Whether I have done any good or not, I don't know.

I remember that at the first annual meeting which was held in Orchestra Hall on Van Buren Street, the Committee on Rail came forward with a report containing a history of the "T" rail which was ascribed to an English engineer, Mr. Vignoles. My ideas were very different. In the lunch recess I hurried up to the library, bolstered up my information and came back in the afternoon and disputed the committee and pointed out that the rail was invented several years before Vignoles by the American

engineer, Mr. Stevens. I don't suppose Vignoles copied Stevens, because in those days there wasn't much communication, and I dare say Vignoles never heard of Mr. Stevens.

Another little incident which occurred several years later was when Mr. Sullivan, assistant vice-president of the Illinois Central, was chairman of this committee, and we met in his office in the present Illinois Central Building. He was much disturbed because of the fact that a yard was composed of yards. A general yard might have receiving yards, departure yards, repair yards, and this sort of yard and the other, and he wanted to get a word which would cover the yard as a whole. There was a lot of discussion, more or less interesting. Mr. Sullivan was very strong for the word "cluster". He spoke of a cluster of grapes. His idea was that we would have receiving yards, classification yards, and so on, to make up a cluster. Nothing ever came of that except that it was officially recommended, but it is too hard to change phraseology, and the cluster went into the discard.

There is another point I might mention in regard to yards, which I didn't mention in connection with the report, and that is that both the English and German railways are advertising extensively in the daily press and the magazines and the technical papers, urging everybody to do their utmost to unload cars promptly and release them for service, and to load cars to their full capacity and to operate the yards at the highest possible speed so as to utilize what equipment they have.

When I joined the committee, yard service was very different from what it is now. It was largely push and pull, flat yards, and what might be called the rattle and bang system. The switchmen seemed to have a great delight in pushing the cars together so hard that they would make a nice loud smash. Now, of course, we have car retarders and remote switch control and teletypes and telephones and all kinds of gadgets.

I think I have taken about all the time that I ought to, perhaps too much, but I would like to express my thanks to the Association for this mark of appreciation. (Applause)

President Bond: I am sure we are all very much obliged to Mr. Mottier for his very able and well deserved tribute to Mr. Tratman. On behalf of the Association, I think it is in order for me to thank Mr. Tratman for his very distinguished service covering the entire life of our Association.

The committee is excused with the thanks of the Association. (Applause)

Discussion on Masonry

(For Report, see pp. 257–355.)

(President Bond presiding.)

Vice-Chairman A. N. Laird (Grand Trunk Western): The first section of the report: Revision of Manual, will be given by the subcommittee chairman, Mr. Boyd.

G. E. Boyd (Railway Age): The committee has two changes to recommend. The first is the reference to the ASTM designation of the Specifications for Reinforced Concrete Culvert Pipe which appears on Manual page 8–90 as C 76–37. The reference as given in the report is C 76–40 T. At the time the report was written, the information that we had was that that revision of the specification was the latest one. Since the report was written, the literature of the ASTM indicates that the specifications were advanced to standard in 1941 so that the designation should be changed from C 76–40 T to C 76–41.

I move that this revision be made.

(The motion was seconded, put to a vote and carried.)

Mr. Boyd: The second recommendation of the committee is that all matter now in the Manual, pages 8–5 to 8–20.4 inclusive, relating to high early strength cement and the Specifications for Portland Cement, and the methods for sampling and testing Portland cement be withdrawn from the Manual, and that the Standard Specifications for Portland Cement shown on pages 259, 260 and 261 be substituted. I so move.

(The motion was seconded, put to a vote and carried.)

Chairman J. F. Leonard (Pennsylvania): The next subject matter in the report of Committee 8 is: Specifications and principles of design of plain and reinforced concrete for use in railway bridges, buildings and culverts. Mr. Laird, chairman of this assignment, will present the report.

Mr. Laird: The report of the subcommittee on design is contained on page 316. The committee has carefully reviewed the subject matter which it has previously submitted on the subject of concrete bridge deck slabs of the non-ballast type (you will find it in Vol. 41, pages 356 to 363, inclusive) and has kept in touch with recent construction of this type. One type not included in the previous report consists of stub or full crossties embedded in the deck concrete similar to the floor design shown in the supplement to Figures 835 and 836 for tunnels with concrete lining on page 8–104.1 of the Manual. This type has been used extensively in tunnel and terminal construction with satisfactory results.

The committee believes that there has been insufficient experience with the various designs to enable it to make recommendations in specification form at this time.

The report is therefore submitted as information.

Chairman Leonard: The next assignment is 3—Progress in the science and art of concrete manufacture. The report will be presented by Mr. C. P. Marsh, chairman of the subcommittee.

C. P. Marsh (New York Central): In view of the pending action on the part of the War Production Board to restrict the number of types of cement which may be produced to allocate production, in order to save freight haul and to centralize the testing of cement, it is doubtful if your committee will be able to make any definite recommendations concerning the use of various types of cement and the practices in marking packages for sometime to come.

This report is submitted as information.

Chairman Leonard: The next assignment is 4—Maintain contact with Joint Committee on Concrete and Reinforced Concrete. Since there has been no meeting of that committee within the past year, there is nothing to report.

The next assignment is 5—Specifications for foundations, including excavation, cofferdam, piling, etc. The report of this assignment will be presented by Professor Vawter, chairman of this subcommittee.

Jamison Vawter (University of Illinois): This bibliography has been confined to current publications and largely to the years 1931 to 1940. Quite a little work was involved in getting it together. The committee hopes that it shall have some use, but realizes that there may have been some omissions of desirable articles. This report is offered as information.

Chairman Leonard: The next assignment is 6: Methods and practices of lining and relining tunnels. The report will be presented by Mr. I. L. Pyle, chairman of the subcommittee.

(I. L. Pyle, Chesapeake & Ohio, read the first two paragraphs of report on Assignment 6, and his motion to adopt the specification as revised, was seconded, put to a vote and carried. He then read the third paragraph on page 330.)

Mr. Pyle: This revision comprises a condensation. I will read the paragraph.

(Mr. Pyle read Paragraph 9 on page 334.)

Mr. Pyle: I should like to call attention to a change which it is desired to make in the paragraph headed "Lime'" on page 331, the second line. Change C 6–34T so as to read C 6–31, the more recent specification having been withdrawn.

With these changes, I move that these specifications be adopted.

(The motion was seconded, put to a vote and carried.)

Chairman Leonard: The next assignment is No. 7—Review specifications for overhead highway bridges of the American Association of State Highway Officials insofar as they relate to masonry, conferring with that association and Committee 15—Iron and Steel Structures. We have nothing to report.

The next assignment is No. 8—Progress in cement manufacture and testing. Since we are combining Assignments 3 and 8, the report on this assignment was presented under Assignment 3.

The next, Assignment 9—Bibliography and review of current engineering literature pertaining to railroad masonry work. There is no report at this time.

The next assignment is 10—Pressure grouting. Mr. W. M. Ray, who is chairman of this subcommittee, is unable to be present. The report will be presented by Mr. Maurice Coburn.

Maurice Coburn (Pennsylvania): Last year the committee presented as information Specifications for Solidification of Masonry Structures by Pressure Grouting. These specifications, with a minor revision, are now submitted with the recommendation that they be adopted and published in the Manual. This revision is as follows:

Substitute for 3 (a): The cement shall comply with AREA Specifications for Portland Cement, Manual pages 8–9, ASTM C 150–41.

I move that this report be accepted for inclusion in the Manual.

(The motion was seconded, put to a vote and carried.)

Mr. Coburn: The committee presents information concerning the grouting of the Chicago subway tunnels as prepared by Mr. A. C. Irwin.

Chairman Leonard: The next assignment, 11—Specifications for concrete and reinforced concrete railroad bridges and other structures, will be presented by Mr. Splitstone, chairman of this subcommittee.

C. H. Splitstone (Erie): This report is found on page 337.

(Mr. Splitstone read the introduction to the report on Assignment 11.):

Mr. Splitstone: In connection with the specifications that are presented herewith, in Section 101, under (d) Resistance to Abrasion, reference is made to ASTM C 131–39. This specification of the ASTM was revised last December and should be now C 131–41. In (e) soundness, the reference should be changed to C 88–41. Reference is made in the specifications to a test for determining coal and lignite in the aggregate. Therefore there should be added item (k) Coal and lignite C 123–39.

As this specification is presented for information only, these corrections will be taken care of before the specification is presented for publication in the Manual.

Section 111, Abrasion Loss, contains a discrepancy which has inadvertently crept into the specifications. The reference to the ASTM standard for determining abrasion loss is C 131–39 which refers to the Los Angeles method, and the limitations of maximum loss by percentage as shown in Section 111 are those which are applicable to the Deval test. This discrepancy will be corrected before the specifications are presented for publication in the Manual.

This report is submitted as information.

Chairman Leonard: I would like permission to remark that this report which has just been presented on Assignment 11 by Mr. Splitstone's committee has involved a great deal of work. If we realize the ultimate purpose which we have set out to accomplish, it will be quite valuable to the railroad industry because the purpose is to attempt to obtain a standard specification which may be used as a general guide for the railroads.

The next assignment is 12—Specifications for test borings, collaborating with Committee 1—Roadway and Ballast. The chairman of this subcommittee, Mr. W. R. Wilson, is now in the service of the Army and will be unable to present this report.

I am therefore asking Professor Vawter, a member of the committee, to present the report.

Prof. Vawter: I am sorry Mr. Wilson could not be here because the bulk of the work in writing the specifications for test borings was his effort.

(Prof. Vawter read the report on assignment 12.)

Prof. Vawter: In line with the recommendation of the committee, I move that the table appearing on page 323, the sample page on 327 and the specifications for test borings on pages 328 to 332 of Vol. 42, Proceedings for 1941, be adopted for publication in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Leonard: Committee 8 regrets to report the loss of two of its most valuable members by death during the last year, Mr. O. V. Parsons of the Norfolk & Western Railway, and Mr. G. R. Smiley of the Louisville & Nashville Railroad.

That completes the report of Committee 8.

President Bond: Mr. Leonard, your committee has certainly submitted a most exhaustive and extensive report. Many of the undertakings were more than what could be expected or desired to be carried out in the course of one year. It is a continuing proposition. We are very much obliged to you for the information which you have submitted. The committee is excused with the thanks of the Association. (Applause)

Discussion on Cooperative Relations with Universities

(For Report, see pp. 175–186.)

(Vice-President Clarke presiding.)

Chairman E. T. Howson (Railway Age): Your Committee on Cooperative Relations with Universities has continued its work during the last year, gaining a new appreciation of the importance of the task assigned to it. The committee recognizes that the railways will face greatly increased competition when the present emergency is passed. It recognizes also that no industry is more efficient than its leadership. Its studies disclose the disconcerting fact that the railroads are no longer attracting the most promising of the young men to the extent that they have done heretofore; but that, on the contrary, they are failing to meet the more aggressive competition of other industries for the more capable young men who are graduating from our colleges and universities.

We find, furthermore, that many of these colleges and universities are not only abandoning instruction in transportation subjects but are discouraging the young men from preparing for service with the railroads. Your committee believes this trend to be of serious concern to railway management, and it is, therefore, endeavoring to acquaint them with the facts.

The situation is not, however, without promising developments. Among these is the awakening of several of our more alert railroads to the importance of initiating measures

necessary to provide adequate personnel in the future, and some of them have progressed sufficiently to secure initial results therefrom.

Also, among the colleges, the response to a number of overtures of the committee has been most encouraging, especially significant being the renewal of interest in this subject on the part of the Society for the Promotion of Engineering Education.

Your committee has had under consideration during the last year five subjects, on all of which it has been working actively.

The first subject, namely, that of stimulating greater appreciation among railway and university officers of the fundamental importance of instruction in transportation and economics, and the necessity for presenting courses of instruction based on current railway conditions and taught by men of adequate ability and experience: Your committee has worked on that subject, has made progress but is not presenting a report at this convention.

Its next assignment was that of calling to the attention of universities and colleges such information and conclusions developed by the Association as would be thought to be of special interest to them.

This committee, under the direction of Mr. Faucette, sent copies of its last report to the presidents and deans of the engineering colleges of the country to acquaint them with the work that the Association has initiated through this committee in their field.

Assignment 3 was to develop means of bringing to the attention of railway managements the value of a technical education as a qualifying factor for young men desiring to enter railway service with a view to advancement.

The subcommittee having that subject in hand has done much work and, under the direction of Mr. Schwinn, chairman of that subcommittee, will present a progress report.

F. S. Schwinn (Missouri Pacific Lines): In this report your committee endeavors to broaden its study and bring to your attention several important influences bearing upon the subject.

Quotations from letters received from railway executives indicate that there is a recognized present demand for technical and other college graduates on the railways. The committee hopes you will give careful thought to these quotations. Some of the facts occasioning this demand were investigated, and we include a few pertinent statistical statements.

The question arises, is the need for such reserve greater now than it was 10 or 12 years ago? To develop this phase of the subject, a few representative eastern and western railways furnished information regarding the average ages of their transportation, mechanical, engineering and maintenance officers of the grades of superintendent and above. These data show that, considering the officers in charge of over 36,000 miles of lines, the average age increased from 51.3 years in 1929 to 55.1 years in 1941. The average officer on these railways is now nearly 4 years older than the average officer 12 years ago, and retirements on account of age will be increased correspondingly. This very clearly illustrates the need of a greater reservoir to meet the future requirements.

While the railways unquestionably have trained and qualified men at present to replace these officers upon their retirement, that fact does not assure them of an equally satisfactory situation 10 or 20 years hence.

There is another factor which enters into the possibilities attached to this phase of the subject. Information at hand indicates that there are probably one-fourth fewer officers at present than there were in 1929. Without discussing the several causes for this reduction, there is the possibility that conditions may require increasing the future

official personnel. Should this occur, promotions should be accelerated; and the difficulty expected in finding qualified men would be greatly increased.

Data obtained from the technical colleges, while showing interest on the part of the railways, does not indicate the aggressive demand for college men which we feel that the backbone of the nation's transportation system demands.

Information was received from 27 colleges and engineering schools located in every section of the country. If you will look on page 181 you will see a short table of comparisons. In 1941, 37 railways contacted technical colleges for the purpose of employing technical graduates. In that same year, those same 27 colleges were contacted by 2,219 other industries.

The comparative figures for 1941 indicate that 49 contacts were made by the railways, and 2,741 by other industries. These returns do not mean that 37 different railways contacted the colleges in 1940, as the railways referred to almost invariably had representatives visit several colleges. But the tabulation does show: 1. Only one out of every 58 contacts looking to the employment of technical graduates was from a railway.

2. Only one out of every 50 graduates placed through such contacts was employed by a railway.

3. There was an increase in the number of contacts made by railways in 1941, compared with 1940 and this was proportionately greater than shown by other industries.

College authorities, while generally cooperative, are not overly enthusiastic regarding the outlook, in the light of this rather low-voiced demand, a barely audible murmur.

I hope you will take the time to read some of the comments that the colleges have made, and I think they were made in the hope they might awaken us.

Your committee's summarized observations covering the past year's study are given on page 185, and these should be very helpful.

(Mr. Schwinn read the summary.)

Mr. Schwinn: Because of the war effort and the rapid expansion of our armed services, there is an insatiable demand in both the Army and the Navy for technically educated men. Such men do not need to come to you now for employment. In order to meet the future as well as the present requirements of the properties you represent, you must now secure priorities for nearly all material items. You are entitled to a high priority for the services of at least some of these men.

During the coming year it is intended to review the practices followed by other industries in the selection and training of college men and to show the importance attached to the employment of such men by those industries.

Chairman Howson: Your committee was also given instructions to stimulate a greater interest in the science of transportation among university and college students and create thereby a greater appreciation of the place of transportation in our national economic structure, cooperating with organizations of university and college students and contributing to their activities in such manner as may be mutually arranged.

This committee, under the direction of Professor W. C. Sadler, chairman, has prepared a report. In the absence of Mr. Sadler, who is in military service the report will be presented by Mr. Lem Adams, a member of that subcommittee.

Lem Adams (Oxweld Railroad Service Company): In view of the fact that this is a rather short report, I am going to take the liberty of reading it.

(Mr. Adams then read the report under assignment 4.)

Mr. Adams: It has been my privilege within the last few years to go before a number of student groups, particularly engineering society groups in various colleges,

and I found that it taxed my ingenuity to keep up with their straight thinking and interest in the subject being presented to them.

This particular phase of interesting college students is well worth while and should be well considered by engineering officers as well as other officers of the railroads. Engineering activities are not the only ones in which we will find the students interested. We could develop an appreciation among many college students, no matter what course they may be taking, as to the advantages to be had in railroad work today.

W. C. Swartout (Missouri Pacific): I have been very much interested in the report of this committee. I would be further interested, if, in Mr. Schwinn's report, he had told us of the average compensation offered by the railroads to graduates of universities.

I was also interested in what Mr. Adams said about the clear thinking of these young men. They certainly are clear thinkers. A great many of the engineering students work their way through college. What the percentage is, I don't know; but a man who has worked his way through four or five years of engineering work bases any decision he makes as to where he shall go, on one yardstick, and that is the one that wasn't mentioned, to wit—starting compensation.

After Mr. Eastman's talk, we can well think that the railroads are carrying the burden of this emergency, and they are, but to what extent are we showing that necessity to young men entering the engineering profession as compared to other industries, and using the same yardstick.

I was told by the director of research of a large industrial company sometime ago that his people considered any engineering graduate whom they took into their organization—they are interested in chemical engineers—was worth a considerable investment of their funds for 6 or 9 months of practical and technical training, which was necessary to fit him to carry on in their organization. In other words, they paid him that much money and received in return a trained employee. At the end of the first year the service they received and the salary they paid about balanced. From then on the young man was giving them as much or more than they paid him.

In the course of the conversation, he said that the young men they took at graduation were, at the end of five or six years, earning on the average, $300 a month.

How many young men starting out, in railroad service—the electricals in signaling, the mechanicals in the shop, the civils on the track—will be earning an average of $300 a month on the railroad at the end of five or six years? There is the answer. I don't know how it can be done. I don't know that the railroads can afford to pay such salaries and, believe me, I am not talking about these engineers who are working for contractors, building defense plants and army camps either. I am talking about those industries that are going to be here when this emergency is over, and yet they lose their men. A man with them five or six years, goes on to something higher. The progress is so much more rapid.

Few men from the institution from which I graduated are in railroad service. Last year, 1941, in the chemical engineering class graduating from that institution there were just two men who did not have jobs when they left school in June that did not pay them $125 a month or more. Those are plain facts.

After all, it is the molasses that attracts the flies, and, unless we give them molasses, we are not going to get the flies.

A large percentage of engineers go to school on borrowed money. They are earnest young men who fully appreciate the help these loans gave them and therefore Item 1 on their financial plan is liquidation of these loans.

Therefore, it is idle philosophizing to talk to these men about taking the long range viewpoint. Of necessity, their viewpoint at the moment does not extend beyond

three to five years. Neither do many of them give much consideration to entering the crafts, driving nails, threading pipe and similar jobs, except those men who feel that shop experience will enable them to be better designing or planning engineers.

Mr. Adams: On this matter of opportunity, I know a young man who came out of college last summer, who secured a job with a railroad in the traffic department. He was keenly interested in his work. Within less than a year's time he had two promotions, after having started at a salary of $100 a month.

The point I want to bring out is that a young man with a college education, not necessarily technical, has a fine place in our railroads today, but the one job that he has before him is hard work.

We can say truthfully that the railroads today offer as much in remuneration as any other field to the young man who wants to get into railroading, in any phase thereof and put forth his best efforts.

Mr. Schwinn: The assignment of this subject did not give the committee the privilege of delving into comparative wages paid in the railroad industry and in other industries to technically educated men.

I think a part, if not all, of Mr. Swartout's question can be answered in the reading of the several letters addressed to the committee by railroad executives and reported in last year's report.

In our own discussions in committee and also outside, I believe it has been our thought that, taken as a whole, wages of technically educated men on railroads do not vary greatly from those in other industries. In some cases I have no doubt you will find higher wages and, in others, lower.

There are also some industries who will advance their men a bit more rapidly than the average railroad. But there are few industries that give the possible ultimate goal to be attained, that may be found in the railroad today.

W. A. Radspinner (Chesapeake & Ohio): When my son was a student at Virginia Polytechnic Institute I found some of the students had organized a railway club. To help out, I sent them some films provided by our railroad, including some that our maintenance of way department had used. It is quite a distance from Richmond to V. P. I., so I could not follow up the activities. Later I found that the enthusiasm gradually died out. I called the matter to the attention of the AREA, but apparently nothing was done about it.

This school is located on a large railroad but neither the maintenance of way nor engineering departments apparently paid any attention to the club. On the other hand, this railroad's mechanical department took the students to Roanoke where they visited the shops. I believe Professor Fish takes the chemical engineering students to water service meetings at Richmond and other places, but again I say the maintenance of way and construction departments do not pay any attention to them.

Not only that; the school has student chapters of the ASME, ASCE, and other national technical societies, but not any of the AREA, simply because no one apparently tries to help organize such chapters in our universities.

I hope the present committee does something along that line, because if it gets a good start in one school, there will be plenty of others to follow up similar organizations.

C. E. Smith (New York, New Haven & Hartford): Mr. Swartout has spoken of the immediate opportunities for college graduates getting out of college and going into railroading in comparison with other industries. I am going to speak on the long-term view. I have had that question put to me many times at New Haven, where each year the Yale students ask me to come up and talk to them.

One day a young man came to me at the depth of the depression and said, "Have I wasted four years taking a technical course at Yale? I don't know whether I can get a job or not. I can go out and be a carpenter at $1.25 an hour."

I said, "Can you? I don't think you can. I think that your getting to be a carpenter at $1.25 an hour is going to present more problems than earning many times that as a college graduate. If you have any doubts as to the value of the education you have had, go over to the Sterling Library tomorrow. Take down the list of Yale graduates and look over the positions of those ten years out and make up your own mind as to whether you would rather be one of those gentlemen or a carpenter ten years from now. If your doubts still linger, do the same for the classes twenty years out, and if your doubts still linger, do the same for the classes thirty years out, and I think all your doubts will have been resolved by that time."

At various times during the last several years I have gone through the list of railroad officers, presidents of railroads and vice-presidents, and looked them up in Who's Who in Railroading and Who's Who in the United States to ascertain their educational background.

We hear a good deal about the College of Hard Knocks through which most railroad men go. College graduates who enter railroading also must go through the College of Hard Knocks just the same as those who do not graduate, but here are some significant statistics: I have never seen any figures to indicate what percentage of all railroad employees are college graduates. I doubt if it can be more than 3 percent, possibly as high as 5, and yet every time that I have made a study I have found that one-third, roughly, a little more or less of the railroad mileage of the United States and Canada has been headed by graduates of engineering colleges; one-third the mileage has been headed by other college graduates, and one-third the mileage has been headed by those who have merely graduated from the College of Hard Knocks, from which the others have also graduated. The percentages vary somewhat from time to time when there is a change on any railroad from a college man to a non-college man, but the general average seems to run on from year to year without much change.

The point I want to make is, in the long term, I believe, college graduates who enter railroad service get what the New Deal is aiming for—security—because they have more regular, continuous employment, more long-term opportunity and a greater opportunity to rise to the top than do those who enter railway service without the college background.

Taking two-thirds of the mileage headed by college graduates as against probably 5 percent of the total railroad personnel, of college graduates, you have there a shot of about 13 or 14 to 1 in favor of the college graduate in his opportunity to rise high in the railroad field.

Chairman Howson: There are young men who have come here today from their colleges, at their own expense, to sit in on this discussion, young men who are in their senior year of engineering and who are interested in and looking forward to a career in railroading.

Might I ask those young men to stand? There are some men from Purdue and a man from Illinois. (Applause)

Vice-President Clarke: We are very happy to recognize you gentlemen.

Chairman Howson: There would have been others but for the recent shortening of the college courses by setting graduation weeks ahead, eliminating the Easter and other vacations in order that these boys can complete their courses in May.

I think we have had the answer, repeatedly, to the point of view expressed by Mr. Swartout. The answer is much along the line of thought expressed by Mr. Smith—

starting salary, yes, but very much secondary to the opportunity; and the railway industry and individual railways are offering opportunities today.

A railway which has been outstanding through the years in offering opportunity to college trained men, and it has deliberately sought college trained men for its official personnel, today has an average age among its superintendents of less than 45. The last three superintendents selected were 37, 38 and 37 years of age. I think that men, young and old, will realize that there is opportunity when recognition comes that early.

We have here today, joining with us in the consideration of this report, representatives of the faculties of a number of schools. I am wondering if time would permit us to have a word from one or two of those.

D. B. Prentice (Rose Polytechnic Institute): This is an unexpected pleasure and obligation to talk to railway men because I came in here as a guest of Mr. Hunley, without any idea of being called on.

I have been in college engineering education since my days at Yale. When I graduated from Yale, a number of men in our class were interested in railroading, and went into it. I think our interest was stimulated by a trip made on the Pennsylvania Railroad, practically as guests of that railroad, an inspection trip to Pittsburgh and various points on the way, including the Altoona shops, where the apprentice school was conducted at that time.

In the interval between 1910 and now, there has been, I say it with some hesitation, although some of you railroad men have already referred to it—a decrease, definitely a decrease, in the interest of young college engineering seniors in railroad work, partly because the compensation has not been as good as it has been in other fields, perhaps, but partly because I don't think you people have been as much interested in them as the representatives of the General Electric and the Westinghouse and the A. T. & T. and Allis-Chalmers, and so on. The representatives of those companies come to the engineering colleges every year. These men from Purdue know how many have come there, probably 100; even to a small college like Rose Polytechnic Institute, 30 or 40 of such representatives will come.

Our present senior class is practically entirely placed, and I don't believe there are more than two or three going into the railroad field. As far as I can recall, only two railroads have sent representatives to Rose. I realize Rose is small, and the men who come there don't have the opportunity to speak to a large number of seniors, but these other companies feel that it is worth while stopping there on their way east and west.

I think if you men will take this matter up with those officers of your organizations who have the responsibility for securing personnel—and it may be in your own hands—you will find that the college seniors and the college faculty will respond very gladly.

I think the decrease of interest in the past 20 years, which I believe is reviving somewhat, has not been due to lack of interest in railroading as such. I think it still has its fascination for the young man. It has been due, rather, to a lack of interest on the part of the railroads, in the young men. (Applause)

Mr. Radspinner: I have taken two sets of bulletins to that school, and they were glad to get them. Some of the engineers had tossed them aside.

Chairman Howson: Might we introduce, without calling on them at this late hour for comment, unless they have something they desire to offer, Professor Rubenkoenig, professor of railway engineering at Purdue, who came with these students.

Prof. H. Rubenkoenig (Purdue University): I might say just a word. I do not entirely agree with everything that my fellow Hoosier has said about the interest of railroads in senior students. Last year I think we had three railroad representatives on the campus; for a good many years before, practically, none. One or two would write in and ask for a man. This year at least six railroad representatives have visited the campus for mechanical engineers. I am talking about the mechanical end of it.

Last year I had 9 students in a course in which I have 19 this year. These boys are all very much interested in railroad employment. I think that is reflected by the percentage of class attendance. It is very seldom that we have a class meeting a week in which the whole student roll is not present. It really takes an emergency to keep them from the class.

I would like to offer only one criticism of the railroads' contact with the universities and that is the fact that they wait until May or June to come after our graduates, the cream of whom has been grabbed by General Motors and General Electric by the preceding November.

Chairman Howson: Mr. Teske of the University of Minnesota came down here as a representative of the faculty, indicating its interest in railroad engineering. (Applause)

There are railroads that are actively seeking, and I think they are successfully using engineers. One of the railroads is represented in this Association by a man who is in the room now. I am wondering if I am at liberty to call on Mr. Akers of the Southern Railway who has sponsored for some years a plan I think he will say is working.

J. B. Akers (Southern Railway System): We have gone in for engineering graduates in a big way on our railroad. We have now in the neighborhood of 60 or 75 who are in official positions.

As far as rates of pay are concerned, we have a number who have advanced as far as Mr. Swartout said—$300 a month. It depends on hard work, application—and willingness to do those things. The race is to the swift in this kind of work. I don't think there is any doubt about that. Give them an education and a desire to follow it up, and there is no reason in the world why they cannot make a success.

We are glad to have such men. We keep a class of about 15 of them all the time—something like that. As fast as men drop out, I mean by promotion, we fill in from the ranks of available college men. We have representatives of most of the colleges in the South, because that is where our territory is, and also we have men from Cornell, Boston Tech, Dartmouth, Michigan, Minnesota—we have them from all over the country.

There is a distinct opening for men of that character, and they can do well if they choose to follow railroad work. It may be said that railroads are not as active in searching them out. I am afraid we are late, as this gentleman said; but we do have our lines out quite a long time ahead. I wrote to Virginia Military Institute a few days ago asking for men we might get a year from now. Of course, this is a poor time to ask for engineering graduates for employment a year from now because of war conditions—but we will get some. We welcome them always.

Chairman Howson: I think I voice the thinking of the committee, both college and railway personnel, when I say that we are thinking not so much of the man who wants a job as the man who wants a career.

I was told this morning of a young man who is pursuing his college course, looking to a career in railroad operation. Because his faculty leader was incapacitated by illness and has been forced to retire, and his place has not been filled, that young man has obtained access to the lecture notes and is continuing his studies on his own. I think such a man is going to have a career, and I think there are enough men who are inspired by the type of work that railroading requires—action, courage, determina-

tion—to provide all the men that the railroads need, and the type of men who will go places in the railroads.

The committee has no further report to present.

Vice-President Clarke: I believe the reinstatement of this committee has been one of the most constructive actions taken by your Board of Direction in some time. The report and the ensuing discussion has been stimulating and challenging.

If there is no further discussion, the committee is excused with our most sincere thanks. (Applause)

Discussion on Maintenance of Way Work Equipment

(For Report, see pp. 187–228.)

(President Bond presiding.)

Chairman G. R. Westcott (Missouri Pacific): We have 14 subjects regularly assigned to the committee. Of these, we are making reports today on seven. With the permission of the Association, I wish to comment very briefly on some of the seven on which we are not reporting, the first of which is No. 4—Self-contained, direct-blow gasoline tampers. It is a rather live subject because the self-contained tamper is making a place for itself in the maintenance of track. However, in years past, the committee had reported development on this; and up to the present, we feel that its previous reports cover the situation rather fully and that there is nothing at the present time that calls for detailed comment.

Subject 8—Mowing machines—is another very live subject, one that has come very much to the front in the last year or so; and we fully expected to report to you on the matter this year. Unfortunately, one of our very valued members was stricken with illness during the season; and it was not possible to bring this report to completion. I think I can fairly promise that next year a complete report on the subject of mowing equipment will be available.

No. 9 is the subject of wire rope as used on maintenance of way equipment. This also is a subject that really calls for consideration, because it is one of the things on which railroad men, I think as a rule, are not very well posted. The work of the subcommittee seemed not as complete as we thought it should be, and that report was held up.

No. 10—Railway owned automotive equipment—Committee 22 made a report on that subject today. Incidentally, I should have called attention to the fact that some of us think that subject should have been continued under Committee 22. The use of automotive equipment, of course, is a live subject, and the function of Committee 27 is to tell you what uses can be made. We are barred from commenting on the economies, which is the prerogative of Committee 22.

Taking, then, the subjects on which we are reporting, the first is: Revision of Manual. Mr. C. H. R. Howe is chairman of that subcommittee, and I will ask him to report for the subcommittee.

(C. H. R. Howe, Chesapeake & Ohio, read the report on Assignment 1 covering recommendations (a), (b) and (c).)

Mr. Howe: The committee moves that these changes be adopted.

(The motion was seconded, put to a vote and carried.)

(Mr. Howe then read the recommendations covering changes in the Glossary, indicating a typographical error in the printed report under the definition of "Push", in the third line, i. e. "level" should read "lever".)

Mr. Howe: The committee moves that those changes be made in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Westcott: The report on assignment 2—Standardization of parts and accessories for railway maintenance motor cars—will be presented by Mr. R. K. Johnson who is chairman of that subcommittee.

R. K. Johnson (Chesapeake & Ohio): I want to call attention to an error in the first line of this report. This is not a final report but a progress report. It includes three plans that are offered for adoption.

(Mr. Johnson then read the report on Assignment 2, omitting the first sentence.)

Mr. Johnson: The committee recommends adoption of Figs. 1, 2 and 3 for publication in the Manual. I so move.

(The motion was seconded, put to a vote and carried.)

Chairman Westcott: Assignment 3—Lubrication of roadway machines. The chairman of the subcommittee is Mr. Angel of the C. & O. Railroad who found it impossible to be here today. Mr. Howe, also of the same railroad, will present the report for Mr. Angel.

Mr. Howe: In this report the committee presents an extensive outline of a very technical, involved subject, one which I do not feel competent of discussing in detail, or attempting to explain. So, briefly, I will try to outline the high spots in the report and its general purpose.

The presentation of this report at this time is most opportune for we are confronted now, as never before, with the necessity of prolonging the life of our roadway equipment; and it is certainly most essential, if we desire to obtain that result, to see that protection and care are given to equipment.

With that in view, on page 200 there is shown Exhibit 1—Lubrication Chart (Maintenance of Way)—which suggests various types of greases and oils that should be used with equipment. Further, to assist in the selection of suitable lubricants, on page 199 there is given an outline for the preparation of specifications for oils and greases, which lays particular emphasis on the fact that there should be a qualification calling for a suitable laboratory and service tests.

In preparing this report, the committee has endeavored to present facts in a simple and direct manner; but it has not been found possible to do so without reference to certain technical terms. In order to aid in the interpretation of these terms, a glossary is given in Appendix A, of lubricating terms, oil and grease, their properties and tests.

Possibly the best summation of the subject in general is stated on page 194 under this heading "Lubricants Cannot Be Standardized":

"Before discussing the quality of a serviceable lubricant, it is necessary to answer the question as to why a lubricating oil or grease for a piece of work equipment after once adopted cannot be standardized for all railroads. As each section of the country has a different crude petroleum base, it would be more economical to use a lubricant from a crude oil supply convenient to the point of use rather than from a distant location."

This report is submitted as information.

Chairman Westcott: Assignment 5—New developments in roadway machines. Mr. Boyd, who is chairman of the subcommittee, will present the report.

G. E. Boyd (Railway Age): I want to call attention to the fact that when this assignment No. 5 was given to the subcommittee, it was the intention to report on developments in roadway machines during the past year and separately for the last five years. When the study was made, it was found that this would be exceedingly difficult for all machines and impossible in the case of men, the difficulties increasing

with the number of companies manufacturing a particular type of equipment. This is explained in some detail in the report.

Because of this difficulty, the general trends in the design and construction of roadway machines were studied; and it was found that there were certain definite trends that could be traced through the entire industry. Therefore, the report was made on this basis.

It was also found in discussion of the subcommittee and the general committee that, as a corrolary, there are a great many unfilled needs now. So, in addition to the developments that have been made and those that are in progress, a section of the report was given over to the important needs still unfilled.

This report is submitted as information.

Chairman Westcott: Color of roadway machines is the subject of assignment No. 6. Mr. Hutchison of the C. & O. will present the report.

N. W. Hutchison (Chesapeake & Ohio): A previous report on this subject was presented to the Association at the convention in 1931 in which it was concluded that medium chrome yellow was the most suitable color for use on motor cars and light work equipment and that black was most suitable for heavy work equipment. These conclusions were recommended for adoption and inclusion in the Manual and now appear on page 27–8.

Unfortunately, the previous report did not specify the exact shade of color intended nor did it refer to any standard specification or color chart from which the recommended color could be obtained. In view of the fact that there are now on the market a wide variety of medium chrome yellow paints which do not match the standard medium chrome yellow, it has been very difficult to specify the required color. Federal Specification No. TT–P–53 covers medium chrome yellow, this color being classified as "War Department Yellow No. 4". This specification did not become effective until 1937, and it is likely that the previous committee had no Federal Specification to which to refer.

Your present committee agrees with the decision of the previous committee to the effect that yellow is the most appropriate color for painting motor cars and light work equipment. However, we have chosen not only a color but a definite shade of the color in order to eliminate the confusion that now exists. The chosen color is commonly known as "Federal Yellow" or "Highway Yellow", and is illustrated by the color board on the table before you. Based upon exhaustive tests by the War Department, and by Federal and State Highway Departments, it has been put into widespread peace-time use for highway markers and for government-owned work equipment, because of its conspicuous visibility against most backgrounds.

There is no government specification for "Federal Yellow". However, it closely approaches "Yellow No. 4" and may be purchased under Federal Specification No. TT–P–53 provided the color specification is met, the only change being that in the composition of the pigment, the total chromium shall not be less than 38 percent lead chromate instead of 54 percent lead chromate. The current report indicates the pigment mixture that will give a color to match "Federal Yellow" and cards of this color may be obtained from the Federal Public Roads Administration.

It is recommended that the color "Federal Yellow" be adopted as the standard color for roadway machines and that this recommendation, along with a color plate illustrating the exact color be submitted in 1943 as Manual material under the subject "Revision of Manual".

I so move.

(The motion was seconded, put to a vote and carried.)

Chairman Westcott: Mr. Ordas is chairman of the subcommittee handling assignment 7—Push cars and trailer cars. He will present the report at this time.

C. H. Ordas (Chicago, Milwaukee, St. Paul & Pacific): The present day motor car being of higher power than those previously used necessitates that push cars and trailer cars be of more substantial construction. We have shown by pictures on pages 214, 215 and 216, representative cars of that type.

Recently manufacturers of materials used in this equipment have developed new types of wheels such as what is known as a demountable wheel, which are very desirable. We have found by questionnaire from various railroad representatives that few of them are using what is known as alloy steel axles. We find it is important that each piece of equipment be properly stencilled, indicating its capacity.

We find, also, that many of the trailer cars used these days are convertible, so that you can use them as a trailer or as a push car. This is accomplished by taking off the seat, and step boards which are detachable, converting the trailer into a push car.

You will find on page 217 a type of push car of the underslung type, used for transporting equipment which is used off the rail.

On page 218 you will find a table showing the dimensions, capacities, and so forth, of the various cars shown by picture on the preceding pages.

It is recommended that this report be accepted as information and the subject discontinued.

Chairman Westcott: Assignment 14—Power and Bonding Drills. The chairman of this subcommittee is Mr. Mills of the New York Central Lines who is prevented by illness from being present today. Mr. Morgan, another member of the subcommittee, will present the report.

C. E. Morgan (Chicago, Milwaukee, St. Paul & Pacific): About four years ago a report was made on power drills. Since that time, it has been found possible to apply other work equipment to the drilling of holes. There is no priority on the application of initiative in the adaptation of machinery purchased for other purposes so that it can be employed to drill holes.

The power drills may be driven by gasoline, electricity or pneumatic motors; and the choice of the most suitable involves a consideration of many factors.

A report of this kind entails a great many details which only the person directly associated with that kind of work would be going into thoroughly. For this reason we have made extensive use again of photographs.

(Mr. Morgan directed attention to the illustrations of the various devices and read the conclusion on page 228.)

Chairman Westcott: That concludes the report of Committee 27.

President Bond: On behalf of the meeting, I wish to thank you sincerely for a very able and constructive set of reports. The committee is excused with the thanks of the Association.

Discussion on Roadway and Ballast

(For Report, see pp. 469–513.)

(Vice-President Clarke presiding.)

Chairman A. E. Botts (Chesapeake & Ohio): On Assignment 1—Physical properties of earth materials: (a) Roadbed. Load capacity. Relation to ballast. Allowable pressures—we have no report. I will report on Assignment (b)—Foundation soils. Settlement. Moisture effects. Consolidation. Lateral flow. Bearing capacity. Piling foundations, as Mr. Legro, chairman of this subcommittee, is not here.

(Chairman Botts read the first paragraph under assignment 1 (b).)

Chairman Botts: Since this report was published in the bulletin we have had a communication from Mr. Hirschthal which reads in part as follows:

"Under Settlement, sixth line of the paragraph, there is a statement: '. . . the water takes practically all the load.' What it really meant is that at the early stages, the load results in squeezing out the water content of the soil, and only after that is accomplished does the soil itself take the stress."

The wording, in his opinion, should be definite and modified accordingly. Mr. Hirschthal, in making that comment, evidently did it hurriedly because the statement should read ". . . the water first takes practically all the load."

After giving that comment consideration and noting that he had left out the word "first" we consider the text as written satisfactory to the committee.

Vice-President Clarke: You are presenting the report as it reads, having called attention to the criticism which was offered by a member but, in the opinion of the committee, the report as originally prepared is preferable and should stand.

Chairman Botts: Mr. Hirschthal further states: "One of the headings under B. Bearing Capacity is Piling Foundations. The heading of 106 is Structural Foundation Soils, and it seems to me that the paragraphs under Piling Foundations do not belong under this heading. There could, however, be included here the practical effect of piles on the bearing power of the soil."

The committee has given consideration to that criticism and agrees the heading should be changed eliminating the word "Foundations" to have it read "Effect of Piling" or "Effect of Piling on Bearing Capacity." On page 473 the subheading "Piling Foundations" will be changed to read "Effect of Piling."

On this same page, the third paragraph from the bottom, there is a sentence reading "In clays, silts," etc. We wish to eliminate the word "silts".

I move that this report as now printed and corrected be included in the Manual as recommended practice.

(The motion was seconded, put to a vote and carried.)

Chairman Botts: Natural waterways, our second assignment, will be presented by Mr. L. S. Rose.

L. S. Rose (Erie): This report covers one method of stream or erosion control. It sets forth its advantages and limitations in such a manner that any great amount of introductory comment seems needless. The committee has endeavored to cover the subject in such a way that it will permit of ready and practical application rather than to expound upon the theories involved.

The theory which was necessarily included has been carried through in a very elementary manner and is illustrated by an actual case. Much could have been included in the report on the subject of velocities, lengths of aprons with relation to height of dams, or the critical flows, but it was feared that too much of such material might

only result in the report being set aside by some who might otherwise use it to advantage. Straining over some relatively minor details is impractical, when we consider that, as a basis for all the calculations, some so-called maximum flow must be assumed, and this flow without doubt will be greatly exceeded at some future time.

The report is offered as information at this time with the intention of offering it for publication in the Manual at the next meeting.

Chairman Botts: The third subject is Culverts, under which we have five assignments. We will present reports on three. On subject (b)—Corrugated metal culverts, particularly types for special conditions—we have no report.

Mr. Swartout, chairman of this subcommittee, will present the reports on the remaining subjects, which will consist of (a) Pipe Line Crossing Specifications for Non-Inflammable Substances; (c) Specifications for Perforated Pipe for Subdrainage; (d) Specifications for Multiplate or Sectional Plate Pipe and Arches; (e) Vitrified Clay Pipe Culvert Specifications.

W. C. Swartout (Missouri Pacific): The report of this subcommittee on Assignment 3 (a) reads: Pipe Line Crossings—Specifications for Non-Inflammable Substances Under Pressure. The words "Under Pressure" should be deleted. The same words as they appear in the second line of the report should also be deleted.

The reason for this is that the specifications cover those cases where non-inflammable substances are conveyed under railroad properties under pressure, but if we put "under pressure" in the heading then we eliminate those crossings which carry sewage or any other material or any other substance which flows by gravity. The specifications are complete in covering both cases.

These specifications were not printed this year because they appeared in Bulletin 423 and in the Proceedings for the 1941 convention.

Vice-President Clarke: Is there any particular high point you think should be called to the attention of the annual meeting?

Mr. Swartout: No, sir. I cannot pick out any particular phase that I think should be stressed. They are all of equal importance to a complete specification.

Vice-President Clarke: Inasmuch as this was published both in the Bulletin last year and later in the Proceedings, all members have had an opportunity to carefully consider it. Since the committee makes the statement that they invited suggestions and criticisms and received none, it would seem to me there is no need to review or repeat all of that material.

The elimination of the printing in this year's report was well considered, in view of our desire to reduce our printing bill, as is so necessary. If there is no objection, we will entertain a motion to vote on this recommendation which is now made very briefly, that this be adopted and included in the Manual.

Mr. Swartout: I move that the specifications as they appear beginning on page 557 of the Proceedings for 1941 be adopted and published in the Manual. I may say that in these specifications the words "under pressure" to which I referred in the beginning of my remarks do not appear. The specifications are correct as they appear.

(The motion was seconded, put to a vote and carried.)

Mr. Swartout: The next subject—Specifications for Perforated Pipe for Subdrainage. These specifications are offered as information for the reason that in our further study of this matter, since the material was passed upon and considered at the last general meeting of the committee in September, there was indicated the necessity for further study of these specifications before they are offered for publication in the Manual. The subcommittee not only welcomes but is asking for your comments and criticism.

The next subject is: Specifications for multiplate or sectional plate pipe and arches. Here, again, is a complete specification. I may say about that, that the subcommittee has continued its study, even after the manuscript for this specification was sent to the secretary. We have found quite a number of additional paragraphs which should be included. As indicated in the foreword of this report, this specification was lifted almost verbatim from the AASHO specification, making such modifications as were required to take care of railroad installations. I don't wish to comment upon the American Association of State Highway Officials specification except to say that we have found that applying this material to railroad use requires somewhat more detailed and comprehensive treatment.

As stated, we desire to retain jurisdiction of this specification for another year. Here, again, we are asking for the help of the members of the Association. We invite your comments.

In the first place, we don't like the words "multiplate" or "sectional" plate. One word is used by one large producer; the other by two other large producers. Both words are featured in their literature. We want to get another word to designate this material, this extra thick plate, which will describe the material and yet not appear to be a trade name. One word that has been suggested is "structural" plate. I don't know whether that is the best word or not. It is a long word. We would like a shorter word.

This is also offered as information. If the members want to use the specification, they will find no trouble in using it in the interim between this one and what we will present next year.

The next subject is: Specifications for extra strong or triple-strength vitrified clay culvert pipe. These specifications appear in full text beginning on page 489. I wish to call your attention to certain typographical errors which have so far been discovered, as I expect to offer this for adoption in the Manual.

In the top portion of the table, on page 491 for size 18 in.—that is size in the left-hand column—going across to "Inside Diameter of socket at ½ inch above base" the figure under "Maximum" now reads 23-13/16. That should be 23-3/16.

In the lower half of the table, under size 12 in. under "Thickness of Socket—Permissible Minimum" it reads 1/16. That should be 11/16. Under size 21, under "Thickness of Barrel—Permissible Minimum" it reads 1-1/16. It should be 2-1/16.

Then, going on down to the note at the bottom, the last sentence should be entirely deleted. The reason is we have taken care of the tolerances in the maximum and minimum specifications, wherever such are applicable.

Vice-President Clarke: The sentence that would be eliminated would be: "The minus sign (—) indicates that the plus variation is not limited."

Mr. Swartout: That is correct. With those corrections covered, I move the adoption of these specifications and publication in the Manual.

(The motion was seconded, put to a vote and carried.)

Chairman Botts: On the fourth assignment—Formation of the roadway: Recent grading projects—we can only report progress. On Part (a) of the fifth assignment—Roadway drainage and recommended practice—we have no report. The report on Part (b)—Effect of locomotive blow offs on track maintenance, collaborating with Committee 13—Water Service, Fire Protection and Sanitation—will be presented by Mr. Tyrrell, chairman of the subcommittee.

H. E. Tyrrell (Southern): The report simply brings out the fact that, except in one case, there has been a solution of the effects of locomotive blow offs on track maintenance; that is, devices have been provided by which the force of the discharge is

eliminated. At other places facilities are provided where you can discharge the blow off into those facilities and get rid of the effect on track maintenance.

The only remaining case is where a switch engine with automatic blow off device is operated continuously or regularly over one stretch of track. Under those conditions, the use of the engine blow offs is liable to increase your track maintenance, cause you to spend more for labor. That is about the substance of the report.

Years ago, when we first started engine blow offs, we did have a lot of trouble with track maintenance all over the railroad but these devices have been perfected, and they are covered generally in this report. If they are used, you have very little effect, except in that one particular case I mentioned.

This report is submitted as information, and it is recommended that the subject be dropped.

R. C. Bardwell (Chesapeake & Ohio): The committee has made a very excellent report. The only thing I might add applies to an explanation which might properly be added to the report.

This is a very timely subject and one directly connected with the increase in efficiency and greater utilization of railroad steam locomotives which constitute over 60 percent of the steam boiler horse power of the United States. During the past decade, there has been an appreciable decrease in the number of railroad steam units, but there has been a remarkable increase in ton miles performed, which means greater utilization of existing units. This could not have been accomplished without a material reduction in the time locomotives are detained in the roundhouse, which improvement was affected to a considerable extent by more constructive attention to the water conditions in the boilers.

It was formerly necessary on many territories to wash boilers every 4 to 7 days, sometimes at the end of each run, but it has been found that, with proper attention to systematic blowing, the engines can be kept in service for the full 30-day allowable government limit.

The statement in the report inferring that blow offs are required by chemical treatment, is not altogether correct because that is only one factor. All water contains more or less impurities, and, as the pure water goes off as steam, these impurities that are in the water, keep on concentrating in the boiler until the water becomes sticky and the steam bubbles do not break but build up on the surface until they finally reach the point where they are carried off with the steam into the engine cylinders, and the engine is said to be foaming. Under those conditions, the engine loses power, cannot do the work, and either has to be taken in and washed out, or sufficient dirty water blown out of the boiler and replaced with fresh water to prevent the critical foaming point from being reached or exceeded.

Under these conditions, it is a great deal more economical to blow part of the dirty water out of the boiler and replace it with fresh water than it is to tie up this expensive equipment in the roundhouse for indefinite periods, remove all the plugs and wash the boiler in accordance with the government regulations. This practice will permit quick turning of the power and provide a great deal more utilization of the very expensive mechanical units.

With this situation confronting the operating departments of the country, it is to be expected there will be an increase over present conditions in this method of handling. Facilities for taking care of the ashes and refuse from coal burned, are taken as a matter of course. It is fully as important that the water side of the fire box be given attention as it is to remove the ash and coal waste on the grates which can be seen.

In the last few years there has been developed an instrument that can be used by roundhouse forces to test a sample of water taken out of a boiler which develops the information showing how much dirty water has to be blown out and fresh water put in, in order to keep the engine in service for a successful ensuing run. This blowing must then be carried out in the best manner possible with the means available.

The report calls attention to the fact that several methods are in use. Considerable development work on this problem has been carried out by the various mechanical departments of the railroads and also manufacturing concerns. Undoubtedly more improvements will be made with further experience.

This is a situation that can not be handled to a satisfactory conclusion by one department alone. It needs the cooperation not only of the mechanical department and water department, but also the track department to take care of these wastes which are blown out of the boiler, which are mostly water without a great deal of sludge as mentioned in one part of the report.

The cooperation of the roadway departments is necessary in helping to solve this part of the problem. It is of vital importance to the railroads and the saving in transportation delay is sufficiently large to warrant the increased attention that is being given this situation. The water engineer can only tell how much blowing must be done. The handling must be provided by others.

In view of the fact that this is a feature of railroad operation that is in the process of development, it is very possible it would be advisable to consider this subject further and make another report at a later date, as the developments are put into effect.

Mr. Tyrrell: I take no exception to Mr. Bardwell's remarks. In fact the committee in its report supports the thought he brings out. But this committee is not concerned with the necessity of blowing engines. Our subject is, what is the effect of this locomotive blowing on track maintenance? We feel that we have told what that effect is on track maintenance. In most cases it is easily overcome and has been overcome by facilities or fixtures applied to locomotives to take care of blowing, but in the one case where an engine is worked continuously over one stretch of track using the automatic blow-down sludge and water is being deposited on the track, it is rather detrimental to the track, particularly in winter, and increases the cost of maintenance.

We don't take any exception, I say, to the blowing of engines but our assignment was the effect of that blowing on track maintenance.

Vice-President Clarke: In view of what the chairman said, do you think the subject should be given further study, Mr. Bardwell?

Mr. Bardwell: I have noticed in traveling around the country that various means are provided for taking care of this drainage, not necessarily the automatic blow off arrangements such as mentioned by Mr. Tyrrell, but the heavy intermittent blowing.

For instance, on the Nickel Plate a portion of the track is paved with proper drainage facilities to carry off this waste. On the Chesapeake & Ohio, we have a number of installations where the locomotive blow off is coupled into a tank. On the Wabash a blow off box is used to take care of the waste when the engine is spotted in front of it and blows into this box. There are a number of other cases where provision has been made to take care of this blow-down, not the automatic but the heavy blow.

I think it would be proper for this committee to present a report giving a review of facilities of this kind that have been put into effect, their respective advantages and disadvantages, and also offer a recommendation as to which is the best type, for the guidance of railroads who are considering such installations. The railroads are resorting to this heavy blowing so they can keep the engines in service and out of the roundhouse. It is a matter of interest and concern to the railroads to know how best to take care

of this situation which is a comparatively recent development, and it will undoubtedly become more important as time goes on.

Vice-President Clarke: The Board Committee on Outline of Work will take note of the suggestion offered by Mr. Bardwell that this subject be studied further, and the report as submitted will be accepted as information.

Mr. Tyrrell: I would like to say one thing in conclusion, that is, it is a little more than the question of drainage. It is a question, first, of dissipation forces and then of taking care of the discharge by drainage or some other means.

Chairman Botts: In our sixth subject—Roadway protection, we have two assignments: On item (b) Stabilization of roadbed: report on methods used—we are not in position to make report on it at this time. Our report on Assignment (a)—Retaining structures—will be presented by Mr. Payne.

(G. W. Payne, Missouri Pacific, read the first two paragraphs under 603. Retaining Structures.)

Mr. Payne: The subject is divided into two sections, Cribbing and Walls. Fig. 1 on page 502 shows a typical timber crib, and Fig. 1a is a modification, stepped at the back.

Precast concrete is in general use. There are a number of types on the market. Some railroads have their own designs and make the units in their own precasting yards. A typical midwestern design is shown in Fig. 2. A metal crib was introduced in 1930. A few years later a bin type metal crib was offered as shown in Fig. 3.

Under Walls we have reported on dry rubble, masonry and concrete. Under Concrete we have had some suggestions and criticisms which will be taken into consideration.

This report is a progress report and is submitted as information, with the request that the subject be reassigned for further study before recommending approval and publication in the Manual. We would like to receive further comments and criticisms during the next year.

Chairman Botts: Our seventh assignment is: Tunnel maintenance. In the absence of the chairman of the subcommittee, Mr. Moore, the report will be presented by Mr. Wall, a member of that committee.

G. B. Wall, Jr. (Chesapeake & Ohio): This report is offered as information, but there are one or two corrections we would like to make. On page 508, the last sentence of the first paragraph should be deleted: "Rails clipped directly to a concrete base would provide an alternate method."

In the second paragraph we should like to delete the last sentence which reads: "Rails clipped directly in the concrete base eliminate ties, but increase the amount of fastenings."

On page 509, under the heading "Watchmen" we should like to make the following correction: "Watchmen are employed in tunnels when conditions justify."

That completes this report which is offered as information.

Chairman Botts: Under the heading "Fences" we have assignments (a), (b), (c) and (d), and we have no report under (c) or (d). Assignments (a) and (b), in the absence of the chairman of the subcommittee, Mr. Jones, will be presented by Mr. Hillman, a member of the committee.

F. W. Hillman (Chicago & North Western): The first assignment—Corrosion resisting fence wire.

(Mr. Hillman read the report on assignment 8 (a).)

Mr. Hillman: This is presented as information.

(Mr. Hillman read the first paragraph on assignment 8 (b), and his motion to adopt the specifications for Wood Fence Posts was seconded, put to a vote and carried.)

Chairman Botts: On our ninth subject—Signs: Specifications and plans for tell-tales—overhead and side, we can only report progress. That is true also of subjects 10 and 11.

Assignment 12 is: Special ballast: Investigate the use of asphalt in ballast. That will be presented by the chairman of the subcommittee, Mr. Podmore. It is a progress report.

(J. M. Podmore, New York Central, read the report on assignment 12.)

Chairman Botts: That concludes the report of the Roadway and Ballast Committee.

Vice-President Clarke: I want to compliment you and your committee on the very interesting way in which this report has been presented. The committee is excused with our thanks. (Applause)

Discussion on Iron and Steel Structures

(For Report, see pp. 363–377.)

(Vice-President Clarke presiding.)

Chairman J. E. Bernhardt (Chicago & Eastern Illinois): The report on the first part of Assignment 1—Revision of Manual—will be presented by Mr. O. E. Selby, chairman of the subcommittee.

O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis): Beginning on page 365, there are listed three pages of revisions of the Specifications for Steel Railway Bridges. With three exceptions, these revisions are of an editing nature to improve the wording and clear up the meaning and do not involve any change in substance or intent of the specifications.

The three exceptions are: Article 432 refers to end stiffeners for girders, and is being revised to include stiffeners for beams.

Article 433 relates to intermediate stiffeners—girders. It is being revised to use a simpler formula, if the formula given may be considered simple. It is at least simpler than the cube root formula which it replaces.

Article 545 involves a minor addition to avoid the use of a proprietary name and, at the same time, accord with current practice in the matter of protective compounds. Those are the three exceptions that do involve some slight change in the meaning of the specifications.

Near the bottom of page 366 there is a minor correction in the printing. Article 701 as listed should read "703" and the page reference should be 15–26 instead of 15–25.

For the reason that, without these changes, Chapter 15 of the Manual will not involve any reprinting, I am not going to move the changes in the Manual recommended in this bulletin.

On page 368 are two items that come under the same category. Article 502, Principles for detailed design of flashing, and so forth, involves a minor addition. In the Fusion Welding, page 15–133 of the Manual, to clear up a misapprehension, it is proposed to revise the article. The revision is slightly different from that printed. I will read the revised wording: Revise the second paragraph to read: "When welding is permitted, it is recommended that the current specifications adopted under the title above by the American Welding Society be used pending further consideration of the subject."

At the same time the first paragraph will be revised to use the exact wording of the title under which the American Welding Society specifications are given out.

The last item is shown at the bottom of page 367. It is proposed to withdraw from the Manual the reference to Specifications for Steel Highway Bridges. I so move.

(The motion was seconded.)

H. L. Ripley (New York, New Haven & Hartford): May I be permitted to ask why.

Mr. Selby: Two reasons principally: One is that of saving space in the Manual. The other is that some people think that highway bridges are not within the province of this committee or this Association, and we are inclined to agree with them. We formerly had specifications for highway bridges. Later they were withdrawn. What is in the Manual now is merely a reference to the use of the specifications of the Association of State Highway Officials. It is proposed to withdraw even that, because when a railroad man has a highway bridge to build, it most probably will be for some state highway department; and in such cases the state highway department properly insists on the use of its own specifications.

(Mr. Selby's motion was put to a vote and carried.)

C. A. Ellis (Purdue University): There are one or two suggestions regarding the revision to which I would like to call attention. If "lineal" is changed to "linear" in Article 202, the same change should be made in Article 211, also in Article 301 (a) with reference to preparing rollers and rockers. In Article 301 (a) I suggest that you delete "stress" in "Stress of extreme fiber of pins" or change the same to "unit stress." I have quite a strong feeling on this confusion between "stress" and "unit stress." A lot of textbooks mix that up. They talk about stress when they mean unit stress, and unit stress when they mean stress. I think that would clear up this point.

In Article 301 (a) do not change "lesser" to "less". See Article 304 where "least" is used.

In the proposed revision of Article 432, end of the second sentence, change "stress" to "load". I simply offer these as suggestions. I don't know that they need any action.

Mr. Selby: I will say for the subcommittee on Revision of Manual and also for the subcommittee on editing that the suggestions just made from the floor will be given friendly consideration. Offhand, I think I agree with them all except the confusion among "less", "lesser" and "least." That is open to argument, but it is not a proper subject for this convention.

Chairman Bernhardt: The report on the second part of Assignment 1—Revision of Manual—Revision of specifications for steel railway turntables—will be presented by Mr. A. M. Knowles, chairman of the subcommittee.

A. M. Knowles (Erie): I will just brief the changes in the specification comparing them with the existing specification in the Manual.

Section I. General Features of Design—Article 101. Types of Turntables, no change.

Article 102. Length. The length of the table is now defined as the overall length of the girders and shall preferably be a multiple of five feet, instead of the length being defined before as the diameter of the pit and a multiple of ten feet.

Article 103. Clearances. The diameter has been increased 2 ft. in width, from 14 to 16 ft., to conform more nearly with our bridge specifications.

Article 104. Power Operation. This is all new material and replaces the old paragraph which read: "Tables 80 ft. or more in length preferably shall be power operated."

Article 201. Loads. No change.

Article 202. Live Loads for Design. The load diagrams have all been changed in Fig. 1523 on page 371, to modernize them in conformity with types of locomotives now in use. This includes making engine axle loads conform more nearly with the Association's standard engine loadings for bridges and the tender loads, and number of axles have been changed to conform with modern tenders.

The special three-axle loading now appearing in the specification as Fig. 1524 has been entirely eliminated. The last paragraph, page 370, under "Live Loads for Design" is new material and intended to provide sturdier pivots and center girder assembly than would otherwise be required by the specification.

Article 301. Unit Stresses. The unit stresses formerly specified for parts which determine the deflection at the ends of balanced tables have been omitted. The former Article 303—Deflection—has been included in 301. The former specifications fixing both the allowable stresses and the deflection were not consistent. The new specifications only require such parts as determine the deflection of balanced tables to be so proportioned that the live load deflection will be limited to ½ in. for 80-ft. tables and for longer tables ⅛ in. more for each 10 ft. of length in excess of 80 ft.

The second and last paragraph of 301 is new material.

Article 401. Bracing: The last sentence limiting thickness of material to not less than ½ in. is new material.

Article 402. Inspection: No change.

403. Protection of Parts: The last paragraph is all new. The first paragraph is the same.

404. Foot Walk: This is all new material.

405. Collector Ring Support. This is all new material.

Article 501. Type of Pivot. The flat-disc type is given preference over the roller type, whereas the old specifications gave no preference.

502. General Features. All but the first sentence of each paragraph is new material.

503. Materials. This replaces all of the old specification material and eliminates the use of cast iron.

601. General Features: The second sentence in the first paragraph is new material, requiring non-adjustable braces for end trucks. The second paragraph allows two wheels at each end of the table as well as the four formerly required. It gives a choice.

602. Wheels and Axles. The old specifications called for cast open-hearth steel wheels or rolled open hearth or Bessemer steel wheels. The new specification specifies the AAR multiple-wear wrought steel wheels used in engine tenders except the rims shall be cylindrical and not flanged and the webs shall be straight.

The last paragraph is new, and ties the material and hardness of rims down to the ASTM specification A 57 and A 236, Class G, respectively.

603. Bearing Boxes. The last paragraph regarding roller bearings is new material.

Article 701. Circle-Rail. The weight of the circle rail mentioned in the last paragraph has been changed from 120 lb. to 131 lb. The last paragraph is new material.

702. Radial Tracks. The last two paragraphs are new material.

703. Rails on the Table. No change.

704. Pit. The first paragraph is new material, providing clearance at the end of the table.

These are the high points of the changes recommended in the specification. It is recommended that they be received as information for consideration and adoption another year.

G. A. Haggander (Chicago, Burlington & Quincy): While I was a member of the committee, I wasn't able to be present at some of the deliberations, and I have a few comments to make on the specification which might be of value in reconsidering it. I think, in general, there are a great many improvements over the old specifications.

Under information to be given to bidders, on page 368, I think we should include the type of end bearing, that is, whether roller or friction bearings, and also the number of wheels at the end of the table, whether two or four wheels.

On the clearance diagram, there is an error in the arrow "for brackets on through tables only"; the arrow should go to the inclined line rather than the top of rail line.

Under loads, I would suggest consideration be given to longitudinal force, either under this paragraph or somewhere else. We have so many tables that are kicked endways by blows against the end rail or by the quick setting of brakes, we ought to make some mention of longitudinal force and make some provision for it by anchorage of the center, and things of that kind.

Under loads it might be well to add another paragraph stating that special loads may be specified by the engineer under special conditions. We have a turntable in connection with the shop where not only the engine but an engine with a "goat" is handled, and the engines that are being handled with this table have the drivers taken out of them. It results in a heavy stress on the table. While there aren't many of those points, we should give them special consideration.

Under the fourth load diagram on page 371, I believe the committee intends that that should be 110 and 115 ft. instead of 100 and 115 ft. because the 100 ft. is covered by the diagram above.

I think that Unit Stresses, 301, using deflection as the basis for design is very good and a big improvement over the old method of specifying.

Under 601 you mentioned the addition of the last sentence of the first paragraph about braces, in which you say the braces shall be non-adjustable in length. We had an experience where the shop could not assemble the entire table and make those adjustments in the shop. In a case of that kind, I think some allowance should be made for adjustment in the field.

702. I would suggest going back to the old specification and adding the following at the end of the first paragraph: "Where wood supports are used at the ends of the rails in radial tracks, steel bearing plates shall be provided."

Paragraph 703. At the end of the second paragraph, add the following: "Rail shall preferably be supported on steel ties at the ends of the table, but if wooden ties are used, steel bearing plates shall be provided."

There are other things regarding turntable pits which it might be well to bring out, as follows: Pave the pit and provide ample drainage. Provide drainage back of pit wall. Provide ample clearance between the steel work and pit paving for snow.

Mr. Knowles: Some of these points which Mr. Haggander mentioned are typographical errors in the printing of the Bulletin, especially in regard to clearance diagram and with regard to the designation for the 110 or 115-ft. table in the diagrams on page 371. His suggestions with reference to inclusion of items in the information to bidders is very good. I think that is very desirable.

This longitudinal force which he suggests be considered is something to which we will give further consideration. It is something that perhaps was overlooked.

With regard to the stipulation of non-adjustable braces in end trucks in Article 601, there may be considerable difference of opinion, but I think Mr. Haggander's exception to that for shops where they are not equipped to lay out the whole table, may be well taken. Whether that should be given exception in the specification or be made an option for the engineer to take care of is a matter to consider.

The consensus of a large number of the members, especially of the subcommittee, was very much in favor of fixing the braces, as to length, in the shop where better adjustment could be made than in the field. We all know this is rather a hard thing to do accurately in the field. The other suggestions which he has made it would be well for the committee to consider.

G. E. Robinson (Cleveland, Cincinnati, Chicago & St. Louis): The committee has provided in Section 202, the third paragraph, an additional 75,000-lb. load for the design of the end of the table, which is slightly over 100 percent impact, with reference to one axle load. Did the committee consider providing a heavier load for the design of end trucks and everything that pertains thereto? In other words, I should like to ask if the committee considered raising that impact above 100 percent.

Mr. Knowles: No, we did not. This is substantially the same as the present specification. We did change the last paragraph in regard to the center, but we did not consider it necessary to make any change in that part of it which you mention.

Mr. Robinson: That is one place where the tables universally go to pieces, and I have within the past year had three, which are all about 14 years old, that have had trouble at the end.

Mr. Knowles: It is very possible those designs did not consider an overload of this nature.

Mr. Robinson: They were modern design. I did not check; they are all patented tables.

Mr. Knowles: The purpose of that, of course, is to provide more sturdy construction there which is recognized as being very desirable, for the same reason 75 percent was added to center girder assembly and 25 percent was added to the pivot.

A. B. Chapman (Chicago, Milwaukee, St. Paul & Pacific): Why shouldn't the turntable loadings be Cooper loadings instead of the loadings you have shown. In many cases we have an engine which pulls another across the turntable and in that case, if we know the Cooper rating, we would know what locomotive could cross. As Mr. Haggander said, if the engine is loaded on special trucks, the rating of the special load could be readily determined and knowing the Cooper's rating of the table, decision could be immediately given for the movement without taking the time to rate the table.

Mr. Knowles: My answer to that is that turntables are subjected to single engine loadings, as a rule, and a standard bridge loading is a combination of two locomotives followed by a train load which is not likely to be handled on a turntable. The loadings selected here are representative of actual engine loadings on many railroads and the heaviest ones have been selected because such heavy loading has to be considered to provide an adequate table to turn such engines successfully and keep down the maintenance to a minimum.

So far as the rating of the turntables is concerned, they can be rated for Cooper loadings after they are designed, under this loading. You can determine the rating as that is a simple matter.

Of course, they could be rated in the standard specification as equivalent of Cooper "E" loading, if that would do anybody any good, but we did not feel that was necessary.

B. R. Leffler (New York Central): As far as rating is concerned, I used to rate them by loading them as heavy as I could and get away with it. I would like to suggest to the committee an addition to the second paragraph of 704. The paragraph reads: "An inspection pit shall be provided in the circle-wall." I would suggest adding, "The pit shall be large enough to take off or put on an end truck assembly."

I think practical experience will show that is a very economical and handy measure.

Mr. Knowles: That suggestion is very good, and it is something that is axiomatically correct and should be considered anyway.

Chairman Bernhardt: The committee has no report to make on Assignments 2 and 3. The committee has no report to make on Assignment 4—Relation between fatigue of metals and bridge design—but I want to call your attention to the reference to Professor Wilson's paper on this subject which appears in Bulletin 426. As you all

know, the AAR is contributing $5,000 a year, the first $5,000 last year, and a second this, to fatigue tests of welds. I would like to ask Professor Wilson to make some brief comments on the influence of fatigue strength of structural members upon the design of steel bridges and also on the progress he has made on fatigue tests of welds.

W. M. Wilson (University of Illinois): There is not time and this is not the place to make any technical report on experimental work that has been done.

As Mr. Bernhardt has said, the AAR is a contributor to the investigation, and it is in order to present before this body a statement relative to the situation.

Specifications for steel railway bridges have contained rules regulating the design of members subjected to reverse loads, for many years, but it has only been recently that we had any considerable amount of experimental data giving us the fatigue strength of such members.

Early European tests indicated that the fatigue strength of small machine specimens is not a dependable criterion for determining or anticipating the fatigue strength of a structural member or a structural joint. What appeared to be necessary was tests of structural members with the same geometry as those used in bridges, and as large as it is feasible to test.

The San Francisco–Oakland Bay Bridge, a few years ago, financed fatigue tests of riveted structural members and joints at the University of Illinois. These tests are reported in the University Bulletin No. 302.

The Welding Research Committee of the Engineering Foundation, through its Committee "F", Fatigue Testing—Structural" is now sponsoring a similar investigation of the fatigue strength of welded joints at the University. This work is financed by the Public Roads Administration, the Bureau of Ships, U. S. Navy, the Chicago Bridge & Iron Company, and the Association of American Railroads. A number of industrial companies have contributed materials and services and the University has contributed laboratory space, heat, light and power and the services of members of the staff.

The investigation has been under way for a period of four years and will probably continue through 1943. The investigation to date consists largely of the determination of the unit fatigue strength of various types of welded joints, as large as it is feasible to test. The specimens of the future will probably simulate more nearly typical details such as are used in bridge construction.

The publication of results from this investigation to date include two reports of Committee "F" and one bulletin of the University of Illinois. These reports are as follows: Committee F Report No. 1, "The Effect of Periods of Rest Upon the Fatigue Strength of Welded Joints" and No. 2, "Calculation and Graphical Representation of the Fatigue Strength of Structural Joint," and Bulletin No. 327, "Fatigue Tests of Welds in Structural Steel Plates."

Two additional bulletins are now being prepared. One will contain the results of fatigue tests of commercial butt welds and the other will contain the results of fatigue tests of fillet-weld and plug-weld joints.

As referred to by the chairman of Committee 15, the writer has presented his tentative interpretation of the fatigue tests that have been made and their effect upon the design of structures in the Bulletin of the Association of American Railroads to which he referred.

The provisions for fatigue of structural members contained in the AREA Specifications for Steel Railway Bridges are satisfactory insofar as they pertain to carbon structural steel but the information relative to alloy structural steels is inadequate for the formulation of specifications covering the design of structural alloy members subjected to pulsating or reversing loads.

Chairman Bernhardt: The report on Assignment 5 was taken care of in the report of the subcommittee on Revision of Manual.

The committee has no report to make on Assignment 6—Progress in design of bridge details.

Subject 7—Rigid-frame design—will be presented by the chairman of the subcommittee, Professor T. C. Shedd.

T. C. Shedd (University of Illinois): The report on assignment 7 is presented as information. I will take time only to emphasize Article 1 in which it is stated: "The current Specifications for Steel Railway Bridges of the American Railway Engineering Association shall apply to rigid-frame steel bridges, except as provided otherwise herein. References to article numbers are to those specifications."

(Mr. Shedd read the subject headings under assignment 7.)

Mr. Shedd: As I said, this report is offered as information, with a view to recommending adoption in the Manual at another convention.

J. H. Shieber (Missouri Pacific): I should like to discuss briefly two or three of the articles in this specification. In connection with Article 8. Impact: "The impact shall be in accordance with Article 206."

I should like to call the attention of this committee to the report of the Impact Committee to be given this afternoon, on Assignment 2, entitled "Tests of steel spans with ballasted decks" given on page 361 of this Bulletin. Inasmuch as practically all rigid-frame steel structures are built with solid concrete decks, with or without ballast, it seems logical that some consideration should be given to the damping effect of this type of deck. I would suggest to this committee that they collaborate with the Impact Committee during the coming year to formulate a clause on impact which will give due consideration to this damping effect.

Article 11. Unit Stresses: This article seems to me to be slightly ambiguous in that it does not specifically show what increase is permissible in the unit stresses, when a combination is made of the primary stresses and those stresses resulting from such loads as temperature change, rib shortening and elastic yielding of supports.

I believe, in formulating a specification of this kind, we should be very specific, and I would suggest that the second paragraph of this clause be changed to read similar to a like paragraph in the specifications for concrete rigid-frame bridges.

Article 13 gives very definite specifications for stiffeners for the two cases of corner construction, that is, one, where the bottom flange of the horizontal member is carried across the vertical member and, two, where the inner flanges of the upright members are made continuous up to the top flange of the horizontal member. But there is no mention whatever made of the condition which is more or less common, of the round corner.

It seems to me that all tests seem to indicate that stiffeners are required at such a corner construction. I think consideration should be given to that.

Mr. Shedd: With reference of the comment on impact, I should like to say that the members of the subcommittee conferred during the preparation of this report with the members of the Committee on Impact, and the Committee on Impact advised us that we do not have sufficient information to be more specific than we were in this particular paragraph.

Mr. Shieber: That is the reason I suggest collaborating this coming year.

Mr. Shedd: We will consider that suggestion very carefully. With respect to the comment on unit stresses, it was the intention of the committee that no increase be allowed when earth pressure, temperature change and elastic movement of supports

were included. It is not our intention to permit any increase in unit stress for combinations of loads that do not include lateral or longitudinal forces.

With respect to the comment on stiffeners at points of bearing, in Article 13, paragraph (3) the statement is given: "Rounded corners at the junction of horizontal and upright members are not considered stress-carrying elements."

The intention of the committee was to eliminate from any consideration in railroad structures the possibility of a round corner. We did not say so in so many words but that was the intention, that round corners are not to be permitted. Certainly, it is true, if they are provided, very carefully designed radial stiffeners are essential.

M. B. Kite (Pere Marquette): In paragraph (b), on impact, is it the intent of the specification to use a different impact factor for each span of a multiple span, for example, a three-span rate where the center span is longer than the end span?

The other question is on paragraph 14 "develop the full value of the member." Does that mean when the full bending stress or shear or thrust is carried by the member?

Mr. Shedd: That was the intention of the committee.

With respect to the paragraph on impact, the committee has not as yet given full consideration to multiple span rigid frames, and for the single span, the length as stated is intended to be the length, center to center of supports.

I would like to read abstracts from a letter written by Mr. Meyer Hirschthal, of the Lackawanna to the chairman of this committee. Mr. Hirschthal writes as follows:

"In paragraph 2, I think some mention should be made of an arched horizontal member in addition to variable cross section."

The committee's reply to that is to refer to the footnote on page 375, in which it is stated:

"The computation of shears, bending moments, and reactions should be made by recognized methods of analysis based on the line diagram formed by the centroidal axes of the members and on the gross moments of inertia of the members."

If the analysis is made on the basis of the line diagram formed by the centroidal axes, it will apply to any shape of member.

Mr. Hirschthal further suggests:

"Under paragraph 4 I suggest a change in wording in the first sentence to read 'or on piles driven to unyielding stratum (rock)' since piling driven to rock is not absolutely unyielding, varying in deformation with the type of soil through which it is driven, in addition to shortening under load. The last sentence calls for a minimum of six inches of cover over the rods which, of course, means in all directions. In all spans this will mean considerable flexural stress."

Presumably if a rigid-frame is used, the tie would be buried in the ground and the encased concrete would be supported by the earth under the tie. Consequently, there should not be any material flexural stress.

"Paragraph 8, no mention is made of impact effects on the vertical member and whether h (height) shall be used or whether the same length (L) shall be used."

Although the committee has not had a chance as a unit to consider Mr. Hirschthal's suggestions, it would seem that since the rigid frame is all one piece, the impact factor should be the same for all sections.

"Under paragraph 9, of all the types of forces mentioned in the first sentence, only that for earth pressure is treated, including the surcharge effect. Recent tests have shown that the pressure and location of the resultant for surcharge loads are very different from those resulting from the Rankine formula, I would suggest omitting

these formulas and substituting instructions to design for surcharge as well as the earth pressure against the sides, without making the Rankine method mandatory."

As I say, I have not had a chance to discuss this matter with the entire subcommittee but I think the suggestion is well taken. It will be given careful consideration by the committee.

Chairman Bernhardt: Committee 15 has nothing further to offer at this convention.

Vice-President Clarke: If there is no further discussion or no questions, this very interesting report is received and the committee is excused with our thanks. (Applause)

Discussion on Highways

(For Report, see pp. 167–173.)

(President Bond presiding.)

Vice-Chairman Bernard Blum (Northern Pacific): The first subject to be reported upon is: Revision of Manual, principally with respect to the sawbuck sign, the painting thereon. Mr. Haigh, chairman of the subcommittee has asked that I present the report for him.

The committee recommends that the following changes be made in the Manual with respect to the highway crossing reflectorized type sign, that is, with the reflector buttons: The background be changed from black to white, and the letters be changed from white to black. That is the reverse of the present standard.

The Joint Committee on Grade Crossing Protection of the AAR, which represents the Construction and Maintenance, Safety, Signal, and Operating sections has so recommended.

I move that such change be made in the Manual.

(The motion was seconded.)

G. R. Westcott (Missouri Pacific Lines): It is perhaps presumptuous to question a recommendation of the Joint Committee, but we have recently gone through an experience that leads me to wonder whether this has been given sufficient thought. The proposal is to make the letters black, the background white, and place buttons in the letters. The buttons, of necessity, will be crystal or white and give a white indication. In ordinary daylight, the indication may be fair enough. If there is a bright sunlight there will be a halo or corona around the button, and the general indication of the button will be white, the same as the background, tending to obscure, to a considerable extent, the indication or the outline of the letter.

Under ordinary circumstances, the buttons will occupy perhaps 25 percent (that is just a guess) of the area of the letter, and with the halo that will form under a strong light as, for instance, sunlight, that percentage may be increased very materially.

During the past year or so on the Missouri Pacific, we had a somewhat similar problem, not with crossing signs but in connection with speed restriction numerals, indicating the maximum rate of speed, where we had fixed speed restriction signals.

Our experience there was that there was a very marked increase in the readability of the numerals when the background was made black and the letters were made white.

In connection with this, I also want to call attention to one or two of the matters that perhaps ought to be considered at this time. There is the matter of the size of the buttons. This Missouri Pacific experience that I just referred to indicated that the smaller buttons give a very much better indication.

In 1935, I believe it was, Committee 6 of the Signal Section, made some investigation of the spacing and the size of buttons; and while I am not entirely familiar with

that report, it is my recollection that the committee stated that in daylight the smaller buttons gave better indication.

The result of our investigation of the speed restriction signals was that the buttons on a figure of about 6 or perhaps 7 in. height, which is a little larger than figures used on these signs—a ⅜-in. button was as large as should be used. This is corroborated by the fact that the better advertisers on roadway signs, where they wish to have a word or a figure stand out clearly, use the small buttons.

Another feature that perhaps ought to be given study is the question of the spacing of the buttons. This was handled to some extent by Committee 6 of the Signal Section in 1935 but I think might well be gone into again.

For the reasons that I have set out, I suggest that before plans now in the Manual be changed, the committee make further studies to determine under all light conditions, including bright sunlight, first, whether the change in color is desirable—that has to do with the background and the color of the letter; second, the best size of button for a 5½-in. letter, and, third, the best spacing of buttons; and further, that the plans not only for the crossbuck sign but all of the signs now in the Manual be revised in accordance with the findings of such a study.

For these reasons I am opposed to the adoption of this material for inclusion in the Manual at this time.

Vice-Chairman Blum: I will endeavor to reply to the remarks rather briefly. I will start in reverse. The discussion on buttons, I think, is out of order. We are not discussing buttons at all, we are discussing the painting of the letters and the background.

With respect to the subject under discussion, I assure you this matter was not passed on lightly by this committee. It has been the subject of discussion for many years. Exhaustive tests were made before the committee changed the colors. As a matter of fact, there is a tendency among a number of railroad engineers to argue against the use of letters at all on the sawbuck, that the shape of the sign is all that is necessary to denote the presence of a track. Therefore, that was one of the important reasons for changing the background to white, so as to have a more visible, general indication of the presence of a railroad track. Certainly, white will show up better in the daylight than a black background will.

With respect to the buttons on the black background, as far as night indication goes, it doesn't make a bit of difference what color your sign is; the reflecting material gives the night indication. Therefore, all we are concerned with, I think, is the daylight indication.

My principal answer is that a large background of white gives a much better daylight indication, and it was so found by this committee. It was so found, I believe—I hope I am not misquoting—by the Signal Section. If I am in error, I am ready to stand corrected.

Several of the states have demanded that we have the white background. I have one or two states in mind that will not permit my railroad to use the black background. They have found from tests and experience that the white background is the better daylight indication, and, per se, it follows that the letter should be black. I think that covers the subject.

Mr. Haigh, have you anything further to say?

A. S. Haigh (New York Central): I was a member of the original committee composed of a subcommittee of Signal Section Committee 6 and one from your section that decided on the original combination. It is a fact that at that time we felt that white letters on a black background provided the best arrangement. This was mainly on the basis of legibility. Our tests showed that the crossbuck having a black back-

ground with white letters was legible for a greater distance than one having a white background with black letters.

The recommendation now before you is presented on a different basis. As stated by the vice-chairman, it has been decided that the legibility of the crossbuck is of minor importance relative to the visibility of the crossbuck symbol and the opinion is now quite widespread, based on experience, that the white background, having a longer range aspect is preferable to the black.

Mr. Westcott: If we are going to have an indication by shape only, then why a reflector on it at all? Very properly, a sign that is not reflectorized at all should have a white background and black letters. When we use the reflector buttons, we get into an entirely different situation.

So far as remarks about the size and spacing of buttons is concerned, I have only this to say: We were told this morning that the expense of Manual revision was growing to be large. If the change is made as proposed on this particular feature, then at such time as the size and spacing of buttons is considered, we will have to revise it again.

Vice-Chairman Blum: I realize that differences of opinion such as this arise, but your committee has studied this matter very thoroughly for more than the past year. I think I have stated the position of the committee.

As far as the committee is concerned, they are ready to leave it to a vote of the Association.

(Vice-Chairman Blum's motion was then put to a vote and carried.)

Vice-Chairman Blum: The next revision recommended is that a note be placed in the Manual, page 9–20.2:

"It is permissible to place reflectorized signs on existing post."

The reason for this being to cover the use of stop signs and number of track signs, and so forth.

Furthermore, that "Stop on Red Signal" and "Stop When Swinging" signs continue to have a black background and white letters where reflector buttons are used, but where the background is to be of reflecting material, it shall be white or silver with black letters.

I think that latter recommendation is necessary so as to have the proper size reflecting medium, which is coming more and more in general use.

Similarly, on pages 9–22, Fig. 904; page 9–23, Fig. 905; page 9–24, Fig. 906; and page 9–25, Fig. 907, be made similar to the Signal Section drawings, the numbers of which are shown. The reason for that is to have one standard between the Signal Section and the Construction and Maintenance Section. The Signal Section drawings are complete, with the necessary pattern numbers and references for the furnishing of the materials. I think that that group is all of one kind. I recommend the adoption of the changes as listed in the last four paragraphs on page 168, and I so move.

(The motion was seconded, put to a vote and carried.)

Vice-Chairman Blum: After Fig. 907 on page 9–25, Signal Section Drawing 1686–B Highway Crossing Flashing Light Signal Assembly, Cantilever type, is to be added.

Beginning on page 9–26 and extending to and including 9–33 a number of Signal Section drawings are reproduced as Figs. 908 to 915, inclusive. These drawings, covering reflector type highway crossing signs, have been revised by the Signal Section to provide for both the synthetic enamel and vitreous enamel finish, together with minor, shall I say, mechanical revisions that the Signal Section has made and which we approve.

It is the recommendation of your committee that the latest issue of these drawings be printed in Chapter 9 of the Manual.

Similarly, on page 9–34.2 and extending to page 9–34.7, are a number of drawings covering highway crossing signs for suspension over the highway. While those drawings have not been issued by the Signal Section and do not carry, therefore, Signal Section numbers, it is recommended that arrangements be made to give them a figure number, under each one of the drawings.

I move that these recommendations be adopted.

(The motion was seconded, put to a vote and carried.)

Vice-Chairman Blum: The next subject of the committee is Assignment 3. In the absence of Mr. Shepard, chairman of the subcommittee, I will present the assignment.

The work consisted in experimenting with new media of reflecting materials, principally Scotchlite manufactured by the Minnesota Mining & Manufacturing Company, and the decalcomania transfer process manufactured by the Cuneo Press in Chicago. These materials, as far as I have been able to perceive, are somewhat similar. I am more familiar with the Scotchlite which consists of fine glass spheres impregnated on waterproofed paper or other medium in a waterproof varnish. It has reflecting qualities not quite as intense as the buttons, but some of us who have used them for a number of years are forming the opinion that it does have a longer life than some of the buttons.

This Scotchlite and similar materials does not seem to be affected by the sun's rays, in discoloration, but retains its original reflecting quality. Some of us have had experimental crossbuck signs of this material up for four or five years, and we can see no difference in the reflecting qualities of the material.

There are on pages 170–172, four photographs. Two show daylight, and two of them night indications, two close up and two at a distance of several hundred feet. I have personally viewed one of these at night from an automobile nearly half a mile away, and with complete legibility of the numbers at a distance of 400 ft., which is about as far as the size letter in question could be perceived in the daylight.

The cost of these signs so equipped is a fraction of the cost of the button signs. With the tendency of a number of states to require self-reflecting signs, sawbuck especially, I believe this material will be of interest to a number of the railroad engineers as it has been to me personally. My road has installed many of these signs, and we are planning on using a great many more.

The next assignment, No. 4—Requisites for location, number and arrangement of automatic signals, automatic gates and auxiliary signs for rail-highway grade crossing protection—will be presented by Mr. Button, chairman of the subcommittee.

(A. P. Button, New York Central, read the requisites under assignment 4, indicating that the word "right" should procede the word "side" in the fourth requisite on lines 2 and 4.)

Mr. Button: The requisites have been given. Their adoption would require certain changes in drawings in the Manual.

(Mr. Button then read the material appearing under "Memorandum".)

Mr. Button: I move that the requisites be adopted.

(The motion was seconded.)

W. M. Post (Pennsylvania): Could requisite No. 2 in any way be interpreted as requiring signals over all regularly operated tracks? I suppose it means wherever signals are used, these are the requisites to be adopted. It seems to me that that could be interpreted as requiring it over all regularly operated tracks.

Mr. Button: That is the intention—that these signals will give warning to the traveling public for the approach of trains over all regularly operated tracks, where any protection at the crossing is required.

Mr. Post: I think you had better be very careful in the wording of that because a great many regularly operated tracks have no highway crossing signals.

Mr. Button: Would a modification of that to read: "Signals, *where installed,* shall give warning to vehicles for trains moving over all regularly operated tracks"?

Mr. Post: That would be all right.

Mr. Button: The committee will accept that modification.

C. H. Tillett (Canadian National Railways): I don't recall (I may be wrong in this) that this has been put before the Joint Committee. Has it been?

Vice-Chairman Blum: I believe these matters came up after the Joint Committee's last meeting. In answer to your question, these requisites have not been adopted or approved yet by the Joint Committee.

If Mr. Tillett has in mind the necessity of such approval before issuance by AAR, I think he is correct. There has been some discussion, through correspondence, among members of the committee, in view of what the Joint Committee approved for the issuance of Bulletin No. 3, that reads as follows:

"The location of signs, signals and automatic crossing gates for railroad-highway grade crossing protection shall be determined after inspection and study at the site. In addition to providing for adequate clearances, consideration shall be given to the type of pavement, angle of crossing and view when approaching the crossing."

I believe there is nothing inconsistent between the committee's recommendation for the more definite location of these signs and signals, and the last requisite which I read. It amplifies the general requisite as covered by the Joint Committee. The Joint Committee's wording requires inspection on the ground, and the recommendation of Committee 9 gives a more specific location to be taken into consideration at such joint inspection on the ground.

Before our work could be put into effect, that is, through approval of the AAR, it would necessarily be referred to and passed on by the Joint Committee; but Committee 9 must first present such recommendations for the further consideration of the Joint Committee.

Does that answer your question, Mr. Tillett?

Mr. Tillett: In a way, yes, but I have been under the impression all the time that the Joint Committee was supposed to give its sanction to the publication of anything with reference to highway crossing protection before it was even put in the literature as a proposed proposition.

Mr. Post: Mr. Chairman, as I recall the discussion in Joint Committee on the proposal that has been read to us, it was the thought that we should not be too specific as to the location of signals at highway grade crossings. I am inclined to think it would be better if this committee presented these recommendations as information at this time and, having presented them to the Joint Committee for discussion sometime during the coming year, would come before the Association for their adoption at the next meeting.

(Vice-President Clarke presiding.)

Vice-Chairman Blum: Mr. Blake, a member of the committee, would like to make a few remarks. Mr. Blake is associated with the Highway Commission of the State of Wisconsin. I think he would like to make a few remarks from the aspect of the highway department.

H. D. Blake (Wisconsin Highway Commission): It is rather peculiar to have a representative of a highway department appear as a member of this grade crossing committee of the American Railway Engineering Association. As a matter of fact, I have been associated with this group for the last fourteen or fifteen years and have worked

along with it in the attempt to eliminate detail and clear up the problems which are presented in the relationship as it may arise between the steam carriers and the state highway departments.

In this particular instance, the matter of the location of railroad grade crossing signals, it appears to me that there is nothing whatever that conflicts in any manner or form with the printed finding of the grade crossing committee of the Association of American Railroads. That document, which is referred to as a yellow covered pamphlet, was printed last spring, at a time when this subcommittee of the AREA Highway Committee had been working on this problem for over a year. Since that time it has completed its report and presents it to this meeting in the hope that some of the detail problems involved in the field location of signals can be eliminated. Many of these problems are not particularly trying or annoying from the standpoint of railroad operation but do involve difficulty when the expenditure of public highway funds is involved.

Personally, I am not too familiar with the relationship between the Association of American Railroads and its subsidiary organization, the American Railway Engineering Association, but this committee presents a report which represents two years of honest, conscientious effort to clear up a lot of ambiguities that have caused a great many arguments and difficulties in the various highway departments and in the signal departments of the railroad companies.

If the matter is put off another year, that will go on for another year—the same arguments, the same difficulties. Perhaps the point brought out by the gentleman from the floor and commented on by Mr. Blum is in order. Perhaps the parent organization should pass upon the findings of the subsidiary organization before it makes any finding.

To an outsider, it looks a good deal like the tail wagging the dog. Here is the American Railway Engineering Association, or a committee of the American Railway Engineering Association, prepared to present a report on two years' endeavor. After that report is presented, if adopted, it can be passed along to the Association of American Railroads for consideration and approval or disapproval of the finding of the subsidiary body.

I earnestly urge as a member of this committee, and as an employee of a state highway department, where we have had occasion to install a large number of railway crossing signals (and expect to install more), that this matter be cleared up, at least as an AREA matter, in the hope that there may be some basic background to which we can both go to settle the various arguments about where a signal should be located.

W. M. Post (Pennsylvania): It seems to me that this committee, in its two years' work has done very well. It has done everything except the last thing it should have done, that is present it to the Joint Committee on Highway Grade Crossing Protection.

As you all know, the Joint Committee is composed of representatives of the AREA. the Signal Section, the Safety Section, the Operating Section, and they have final say on grade crossing matters, so that there would be no confusion between the different organizations of the AAR.

Vice-Chairman Blum: The only answer I can give to the last speaker is that this matter was decided on, as I said, subsequent to the last meeting of the Joint Committee. I appreciate the arguments that have been made on both sides, and the time is fleeting. To clear the matter up, it is my suggestion that, if the subject matter meets the approval of this meeting, it be withheld from publication, pending favorable action by the Joint Committee so that it can be decided on without waiting another year. In other words, I am asking for final approval of the AREA to the end that it can be submitted currently to the Joint Committee for quick action.

If I may make that in the form of a substitute motion, I would request that you so present it to the floor.

(The substitute motion was seconded.)

Vice-President Clarke: This is certainly an important point. We do not want to be hasty in the action that we take, and yet it is desirable that we make progress. We have the highest regard for Mr. Post and the opinions of the Signal Section, which he represents.

Mr. Post, are you willing to accept the suggestion which has been made by the vice-chairman?

Mr. Post: I think that would be perfectly all right, provided it is not published in our Manual until it has received the approval of the Joint Committee.

Vice-Chairman Blum: That was the intention of my motion.

(The substitute motion was put to a vote and carried.)

Vice-Chairman Blum: That concludes the report of Committee 9; but I desire to call attention to the memoir on page 168, which records the passing of Paul M. Gault who for many years was a member of this committee and a very valued member of the Signal Section. I am sure the entire Association as well as Committee 9 will feel his loss.

Vice-President Clarke: We certainly appreciate the work this committee is doing. It is excused with the thanks of the Association. (Applause)

Discussion on Wood Bridges and Trestles

(For Report, see pp. 243–255.)

(President Bond presiding.)

Chairman R. P. Hart (Missouri Pacific): The report of Committee 7 consists primarily of material offered under only one of the eight subjects assigned to this committee.

Under Subject 1—Revision of Manual—quite extensive revisions were made last year, particularly under Subject 2—Simplification of grading rules in order to effect conformity with current lumber standards. There is one revision of the Manual which was considered but was not offered to the Association. That consists of the question of deleting reference on page 7–69 to specifications for wood highway bridges. Committee 7 understood that Committee 15 intended deleting reference to the same specifications, and that matter was acted upon this morning. Committee 7, however, feels that as this reference to the specifications of the American Association of State Highway Officials covers only one paragraph at the bottom of page 7–69, it would let the matter rest for the time being. There is a feeling, also, that, somewhat contrary to the opinion expressed by Committee 15, bridges designed by railroads are not likely to be those in which the state highway departments have an interest but bridges in which local communities, townships, counties have an interest and, in many cases, do not have an adopted specification to follow.

Subject 3—Overhead wood or combination wood and metal highway bridges, refers to the same matter. Material now in the Manual is not as complete as it might be; and we would like to continue this work to give further consideration to different types of floors, including some new types which are giving very satisfactory service, and particularly the combination floor of concrete and laminated timber.

The meat of Committee 7's report this year is found under Subject 4—Specifications for design of wood bridges and trestles. I am sorry that we do not have with us today Mr. John A. Newlin in charge of division of timber mechanics, U. S. Forest Products Laboratory at Madison. Mr. Newlin has rendered valuable assistance in fur-

nishing information upon which the specification which we now offer you is based. I will ask Mr. A. B. Chapman, chairman of the subcommittee, to present this part of the report.

A. B. Chapman (C. M. St. P. & P.): Last year your committee presented as information a tentative draft of specifications for the design of wood bridges and trestles for railway loadings and requested comments and criticism thereon. These specifications have been revised and are now submitted with the recommendation that they be adopted for publication in the Manual.

(Mr. Chapman read the foreword under Assignment 4.)

Mr. Chapman: Table 705, for example, giving specified working unit stresses, conforms exactly to Forest Products Laboratory recommendations.

(He read the headings under General Features of Design.)

Mr. Chapman: On page 246 are given deflection coefficients for the determination of distribution of loads to piles of timber trestles for five-pile and six-pile bents. The next page, 247, gives the distribution of loads to stringers of timber trestles as they receive the load from the ties.

(He concluded the reading of the headings.)

Mr. Chapman: That completes the report of the subcommittee. I move that it be adopted for inclusion in the Manual.

(The motion was seconded.)

B. R. Leffler (New York Central): I am critical of some of the English. In the last paragraph of the foreword I do not get the meaning of this sentence: "Seasoned timber acquires a permanent set under long continued loading. This set is about equal to the short time deflection." Set and deflection are used as equivalent, which I don't believe is correct. Using moduli of elasticity hasn't anything to do with this permanent set or deflection. It is used only as a means of calculating what the probable deflection would be. It also says: "The ultimate deflection under long-continued loading will thus be about twice the short time deflection." The word "thus" makes that sentence an inference from the preceding sentences in that paragraph, and I can't see that it is an inference at all. It may be stating a fact that the deflection is twice but not because of "thus."

I have made the following suggestions as to the revision of this, granting that I understand it. If I don't understand it, it is because it hasn't been originally written correctly or because my comprehension is short.

"Seasoned timber acquires a permanent deflection under long continued loading; this deflection is about equal to that caused by a short continuation of the same loading."

That is my interpretation of the meaning of the first sentence of the paragraph under discussion. In addition, I criticize the paragraph still further. Three different terms are used which are in a sense equated to each other. They may be synonymous. There is the term "set", the term "deflection" and the term "sag." All three of those terms have not identically the same meaning, but they may be classified as synonymous. I think it is highly improper to use synonymous terms in a technical specification. The most general term should be used that covers all of the properties of the material that is under discussion. I suggest the committee revise this.

Further, on page 248, in Article 203. Live Load—the language is a distinct violation of sound reasoning, as I will point out to you. It says that an effect is equivalent to an engine or a trainload. There is no such thing as that. Effect can never be equal to or the same as a cause. I would change that to read, "Load per track shall consist of that Cooper loading which will produce a loading effect equivalent to that caused by any engine or train to be moved over the completed structure."

I am a stickler for making our Manual the finest example of clear English. I want every engineer to be able to write good English, better than any lawyer writes it.

Mr. Chapman: In regard to the last paragraph under the foreword, the committee feels that the term "permanent set" is applied exactly as it should be. The set of a timber is something entirely different from deflection. Deflection is caused in timber by a load quickly applied, or that can be computed using the normal modulus of elasticity of timber. The committee had considerable discussion on that point. I am sorry Mr. Newlin is not here today; but he assured us that those two terms, "set" and "deflection", are entirely different in timber structures.

We feel that the terms "set" and "sag" each have their own meaning. A timber sags due to the long span, and the load on it. It will sag without any load, of its own weight. But that isn't set. If it is left with the load on it long enough, it will take a permanent set, and will not come back. So we feel that each one of the terms in that paragraph is the proper one to apply.

President Bond: The definition "permanent set" as contained in the Manual reads: "The permanent set is the strain or deformation remaining in a body after being stretched beyond the elastic limit." Would you consider the words "permanent set" in this expression here to conform exactly with the definition in the Manual?

Chairman Hart: No, sir. I would like to see a revision of that definition in the Manual to apply to timber. That does not apply to timber as now defined.

President Bond: I think that point is well taken.

Mr. Chapman: As to the other changes suggested, page 248, Article 203, under Live Load, the committee is agreeable to accepting the revision except that the last portion of that paragraph should be retained, including therein "during its expected life".

President Bond: There is a motion before the meeting; and, as I understand it, you contend that the paragraph at the concluding portion of the foreword is in order as it stands, but you accept a modification of the first paragraph under 203.

Mr. Chapman: Yes.

President Bond: Would you mind explaining to the meeting how you would rewrite that paragraph 203?

Mr. Chapman: I am not sure whether I got it just exactly as Mr. Leffler stated it. "The live load per track shall consist of that Cooper loading which will produce a loading effect equivalent to that caused by the maximum engine or trainload expected to be moved over the completed structure, during its expected life."

President Bond: Then your motion includes that modification of the paragraph as you have read it?

Mr. Chapman: Yes, Sir.

Mr. Leffler: May I ask why the committee wants to retain the word "maximum". The word "maximum" in there doesn't seem to mean what it might mean. Does it mean the heaviest engine or the one that produces the greatest momentum or the greatest shear, or what? I thought it advisable just to delete the word "maximum". Every engineer who figures stresses knows how to handle a locomotive. The word "maximum" doesn't convey the meaning to me that it usually does. Otherwise, Mr. Chairman, I am agreeable to the revision as agreed upon.

Mr. Chapman: In leaving in the maximum there, we wanted to make sure that the designer used the heaviest engine that he expected would be used. We thought this would be a precautionary effect more than anything else; instead of designing for one particular engine, he should design it for the heaviest one expected. We still think maximum should be retained.

A. M. Knowles (Erie): Speaking of maximum engine, the tender of the engine might have the controlling influence on the particular member under consideration, and

it might not be the total maximum engine or locomotive that would cause the greatest stress, as Mr. Leffler said.

Mr. Chapman: You are right, the tender many times does cause the greatest stress. We have shown the maximum engine or trainload which covers whatever load might be in the train.

G. A. Belden (Central of Georgia): May I ask if the adoption of this specification will require changes in the present standard plans?

Mr. Chapman: There will be some changes, and undoubtedly the new plans that will be made will conform to this specification. That is the intention, isn't it, Mr. Hart?

Chairman Hart: Yes.

Mr. Belden: Then if this specification is adopted, those present plans would be obsolete as far as they go now?

Mr. Chapman: That is the understanding.

Chairman Hart: I might answer that by saying the plans have been up for revision for the last two years, but we feel that we should have this basic specification to form a background for those plans before we offer the revised plans.

J. B. Hunley (New York Central): I should like to call the attention of the committee to some errors in the table on page 246 which purports to show the distribution of load to the piles of timber trestles.

For the five-pile bent, the last term in equation (3) should be preceded by a plus sign instead of the minus sign; that is, $+4(30)^3$. Equation (9) which expresses the value of U, or pile shortening, is incorrect. In the derivation of that you have used the length of pile in feet and the diameter in inches. If anyone had taken the trouble to experiment with it, he would have found an uplift on the outside pile of a five-pile bent. In other words, to correct that equation, the 9.55 in the numerator should be multiplied by 12 to convert it into inches, making that term $\frac{114.6}{E}$, and the second term of the fraction should be divided by 12, or that fraction should be $\frac{1}{14 - .0111\ L}$.

I don't know to what extent the committee expects these formulas to be used, but it is interesting to me, at least inasmuch as it condemns the five-pile bent and shows that the four-pile bent provides a somewhat better distribution. With the five-pile bent, assuming that the piles are spaced 2 ft. 6 in., centers, the center pile carries 23 tons while the outer piles carry only 7.8 tons. These figures are for 12-ft. panels and E72 loading. With a four-pile bent in which the spacing of the piles, beginning at the outside, is 2 ft. 9, 2 ft. 6, 2 ft. 9, the outer piles carry 18 tons and the inner pile 24 tons. This is a very much better distribution.

If this formula is to be used, I think the committee should have included the cap compression. We know that the modulus of elasticity in tranverse bearing, of any material ordinarily used in trestle caps is very low. It is probably less than 100,000 lb., and the cap compression per inch of depth for the same load would be about 16 times what the pile shortening would be. The inclusion of this factor gives a different distribution which is still more favorable to the four-pile bent, and less favorable for the five-pile bent. I question, even with this refinement, whether any of the formulas actually represent the true conditions, because it is very difficult to saw off a pile to within 1/16 in. of a true plane, and they are of course, based on a true surface of the pile cut offs and a true surface on the cap. Article 104 contains the statement: "An approximate analysis to determine the division of load among the several piles of a bent is given in the chart, Fig. 720." If the formulas are not taken too seriously, it is all right; but they can scarcely give an accurate distribution of the load to the piles. I am not suggesting that it be taken out, as it may be of some interest.

Article 203. Live Load. This specification, if it is taken literally, leaves the loading to the imagination of the designer. In the Manual there are designs of trestles for E72, E60 and E45 Cooper loading. You may be referring to one of these three loadings, when you refer to "that Cooper loading," but it is not so stated.

Prior to 1935, the specifications of the Committees on Masonry, Wooden Bridges and Trestles, and Iron and Steel structures all provided for a different loading, and the Board of Direction in July 1935 appointed a special committee consisting of three representatives of three main committees to arrive at some uniform practice. That committee met on October 4, 1935, and the report to the Board read:

"Your committee recommends for the live load to be used in designating structures carrying tracks, Cooper E72 load as shown", making reference to the diagrams in the Specifications for Steel Railway Bridges, and that, "Where a different live load is desired, the engineer shall specify the load to be used; such load shall be proportionate to the recommended load with the same axle spacing."

Apparently this committee has ignored that report, or the Board has changed its mind. I find the Masonry Committee has since revised its recommended live load as it refers to the "standard AREA live load." While "Standard" isn't defined, presumably it refers to the live load designated in the Specifications for Steel Railway Bridges. Would there be any objection to your committee using the live load in the steel bridge specifications, which recommends E72 loading as a standard but permits the engineer to specify a different loading when justified? It seems to me we should get together on a common live load for this Association.

In Article 201 which defines the load to be considered, you provide for dead load, live load, and centrifugal force. I understand why this committee did not include impact forces, although I do think it would be well, as a matter of information, if you mentioned here why the inclusion of impact is not necessary, with the exception of one item. In the design of steel railroad bridges we have as one of the causes of impact the effect of roll, which is defined as an increase on one rail of 20 percent of the live load, with a decrease on the other rail. I think that is something which should be provided for in your design. It is just as real as the live load, and it isn't dynamic in the effect, in the sense that a hammer blow is dynamic, but it is there, and I think it is more important than some of these other forces which you are providing for, such as lateral and longitudinal forces.

I don't ordinarily criticize the wording of a report, but there is one thing that looks a little strange in Article 208. You refer to the modulus of elasticity as a working stress. That is a new idea to me.

May I move to amend the motion to adopt so as to provide, under Article 203, that the live load be specified as that given in the specifications for the design of steel railway bridges?

President Bond: According to our Constitution, "an amendment which affects an underlying principle, which yours does, if adopted, shall of itself constitute a recommital of that part of the report as the committee considers effective." It has to be referred back to the committee. That is the basis on which we work, but that doesn't necessarily prevent you from making the amendment.

Mr. Hunley: I move this be referred back to the committee for reconsideration. What I am trying to do is to have one or two of what I thought were major items revised so that the report could be adopted by the Association this year, one way or the other.

Secretary Lacher: I think the reason for the rule or regulation to which the President just referred is to prevent just the sort of action that has been proposed here, and

that is an attempt to fix up or otherwise adjust a difference of opinion here in convention, on the ground that such attempt would in most cases be ill advised; that it is impossible in the short time at our disposal here to make such adjustment and have it in just the form that it should be. In other words, if something needs adjustment, the proper way to do is to recommit the document to the committee.

Mr. Hunley: Those two points, it seems to me, are quite important in a specification of this sort; but I dislike holding up this thing for another year. That is what a recommitment will mean.

President Bond: But the convention is hardly equipped or intended to do committee work.

Mr. Hunley: Very well, I will withdraw my motion and move that this specification, Articles 201 and 203 be recommitted to the committee.

Mr. Leffler: I will second Mr. Hunley's motion to resubmit those articles he named, and I would like to briefly state why. It is a very common academic error, when you have a lot of formulas as shown on pages 246 and 247, to get inches and feet mixed up; and the committee should adopt either all feet or all inches, to make that part very clear. Mr. Hunley has pointed out one or two cases already. I think those two formulas should be scrutinized very clearly.

Chairman Hart: Does that mean that the entire specification will have to be carried over for another year?

President Bond: It will have to be carried over for another year until it is complete. We couldn't put it in the Manual piecemeal.

Mr. Hunley: The criticism in 201 is that the impact is not included.

President Bond: Also the corrections in the formulas.

Mr. Hunley: That, I take it, is part of 201. Then I have mentioned 203, covering live load, to reconcile it with the action that the Board asked for. Also, if the matter of impact is not mentioned in 201, it will have to be put in as a part of the live load. Those are the particular points that I am trying to cover.

Chairman Hart: In answer to the criticism on paragraph 201, I would like to say that the consideration of impact is deliberately omitted because the extensive tests made at Forest Products Laboratory show conclusively that sticks of timber will carry a moving load which, if allowed to stand on that same stick, will break it. The conclusion from these tests is that no impact should be considered in the design of a timber structure, impact due to moving load.

Mr. Hunley: I think you have misunderstood me. I find that a great many people do not understand that the dynamic force or impact, as you call it, need not be considered in designing timber structures. I know some very prominent engineers who design steel structures and do not realize it. I have known college professors who were rather amazed at this fact. The only reason that I suggest that the rolling load be included is that it is one of the items of impact. I am not asking that you take into account any low joint or hammer blow effect. If you want to disregard the word "impact" in 201, under 203 simply say that the wheel loads of the locomotive or the train loads shall be increased 20 percent on one rail, and don't call it impact, but it is just as much a force as the static weight of the locomotive. It is applied neither faster nor slower than the locomotive load, but is simply a transfer of weight from one side of the locomotive to the other. It isn't a dynamic force, and it isn't treated as a dynamic force in the impact formula. If you will include it as a live load force, you need not change 201; but if you wish to call it an impact force, as Committee 15 does for steel structures, impact should be mentioned under 201.

Chairman Hart: The reason the rolling load has been disregarded is because it is, in a way, an impact load. It is an increased load, true, but it is a momentary load,

and the momentary increase is not sufficient to offset the carrying capacity of the timber for that momentary load.

Mr. Hunley: I can't agree with you on that. It is a very slow motion, not over twice a second. Sixty miles an hour is 88 ft. per sec., and in ½ sec. the load will pass over 2 or 3 panels, during which time the excess may be all on one side. It isn't a load which changes rapidly. It has a fixed frequency, in the neighborhood of 2 to 3 times a second, so that on a single panel of stringers it is there during the time that the locomotive is there. Such an allowance also provides for the difference in weight on the drivers of locomotives, which we know from the scale tests, may run as high as 10 and 15 percent, without roll even when the engine is not in motion. I think you should include it.

Chairman Hart: It seems rather strange that the chief criticism to this specification should be directed at points which are already adopted material in the Manual. The matter of sag as being differentiated from deflection is covered in Paragraph 7 near the bottom of page 7–108 under "Notes on Stress Grades" which have been Manual material since 1938.

This matter of impact is covered in Paragraph 1 of "Notes on the Use of Stress Grades" page 7–107 adopted at the same time, as Manual material. For your benefit, I will read it for you:

"Working values may be used without allowance for impact up to impact of 100 percent of loads figured. The ability of timbers to support loads is very dependent on the duration of the stress. Tests have demonstrated that the load required to break timbers in several years is about 9/16 of that required to break them in ordinary laboratory tests. When the time is shortened still further, as in impact loading, the load required to break a timber is correspondingly increased. Approximately this increase is 10 percent when the time is reduced 1/10 of the previous time. Working stresses for 5-min. loading may be increased 50 percent over those for long time loading."

Due to the fact that we already have in the Manual material which substantiates the clauses which we propose to put in this specification, I feel that we should adopt the specification as it is and avoid deferring it for another year, in order that we may proceed with the revision of plans for trestle construction.

Under Paragraph 203, Live Load, the committee had no intention there of ignoring the wishes of the Board of Direction in this matter of specifying live load. With the thought that so many of our timber trestles are located on branch lines and on lines where the loading is so much less than E72, it was thought it would be better to specify it in this manner. In other words, we design a steel structure or a concrete structure which is expected to have a long life for a certain fixed loading. Trestle bridges are often built for short duration and for a particular loading which is much less than a loading which might be adopted for a long time loading.

Mr. Hunley: Of course, the specification for loading which I suggested permits you to decrease that loading wherever you are warranted in doing so. But with this specification which you propose to adopt, what loading would you use in your modified design? It doesn't tell you a thing as to that. What would you use? You don't mention any value for the Cooper's loading.

Chairman Hart: I would modify it to such Cooper's loading as would give me an equivalent effect to the loading which I intended to move over the structure, just as the clause reads.

Mr. Hunley: I understand you are going to revise your standard drawings of timber trestles as soon as this specification is adopted. Of what capacity trestles are those standard drawings going to represent?

Chairman Hart: They will provide for various loadings.

Mr. Hunley: Why don't you mention them here? They now start from E72 and go down. Why can't you put E72 as the maximum and provide lighter loading? You are permitted to do that under the wording I suggested.

Chairman Hart: We thought that that was something which could be easily selected by the party who was going to use it. It is put here in a way that we thought was a little more flexible.

Mr. Chapman: The discrepancy in units in the pile shortening formula of Figure 740 on page 246 can be readily corrected. Curves were made up to show what load is carried by each pile of typical bents; these show definitely, just as is found in practice, that the inner piles take the most load; for example, in a five-pile bent, the center pile and the next two piles each take practically the same load, while the outside piles take only about 15 percent of the load, so it bears out results which have been found in practice. Wasn't that one of the points?

Mr. Hunley: I just called attention to a correction in that table.

(Mr. Hunley's amendment was then put to a vote and carried.)

President Bond: The ruling from the Chair will be to the effect that the amendment having carried, the original motion is lost and the report goes back to the committee.

A. M. Knowles (Erie): May I add one more suggestion for the committee's consideration? I notice that page 245, Article 106, Ties, specifies that on open deck bridges the ties shall be spaced eight inches apart. I am wondering if that is different from what is specified in the steel specifications which provide that they shall be not more than six inches apart. I wonder if the committee has considered that distinction.

Chairman Hart: We have considered that, and we decided that was what we wanted.

Mr. Leffler: It seems to me that the point raised by Mr. Knowles is well taken. Why eight inches for wooden and six inches for steel?

Chairman Hart: It isn't so much a question of the bending under ties of timber trestles. You have a much wider bearing for your tie. Practice has indicated that eight inches is satisfactory, and the clause here says that the maximum clear space between them shall be eight inches. In other words, it leaves the leeway of specifying a closer spacing, if the designer prefers. We have had a great deal of discussion on that particular point in our committee, and it was first set up to follow the steel bridge specification of six inches maximum but we had so many cases cited to us where satisfactory results are being obtained with an eight-inch spacing, we thought we would allow that leeway.

Mr. Leffler: We have steel bridges with the stringers three and four under a rail, which would occupy the same relative position to the center of the rail that timber stringers do. If eight inches is allowable for timber stringers maybe it should be allowable for short span I-beam bridges in which the stringer is usually directly under the rail or the set of stringers is centered under the rail.

Mr. Chapman: I just wanted to state that the Milwaukee Railroad has for the last two years been using an 8-in. spacing between ties on steel bridges as well as on timber bridges, and with very satisfactory results. I know of other railroads that are doing the same thing.

Mr. Leffler: Then Committee 15 ought to revise the specifications. I am just talking from the standpoint of consistency. Two committees here are specifying for the same thing, giving different recommendations. It doesn't look quite right.

Mr. Hunley: Under Committee 15 specifications ties are designed for bending, and if the girders are 6½ ft. apart, with an 8-in. tie you ordinarily cannot space them more than 4 in. apart. It has been my practice, where we have had a group of beams under the rails, as you have with stringers to increase the spacing where bending isn't involved. The only difficulty in placing the ties too far apart, especially if you are using treated ties, and they are sap or boxedheart ties is that they crush unless you use a very heavy or double-shoulder tie plate.

It isn't a question of bending, it is a question of whether your tie will support that load in bearing. As long as you specify a maximum spacing of eight inches, I think it is all right. We have always used six inch spacing for timber trestle decks or where the steel stringers were under the rail. Where you have bending in a tie, the girders have to be quite closely spaced or the loads quite light to get by with even six-inch spacing.

Chairman Hart: We will be very happy to have further suggestions from any member of the Association. In fact, the drafted specification last year was presented for that purpose. We felt though, since we had not had very much, if any, criticism of the draft last year, that we were on pretty good grounds to ask you to adopt it as Manual material this year in order that we might proceed. But since you have elected not to do so, we will try to put it in satisfactory form for you for another year. The chairman of two subcommittees, Mr. H. C. Heinlen has been called to military service as a major in the Coast Artillery. In addition, this committee has also given up Major Hugh Everett, Jr., and Major J. V. Johnston who are now in active service.

The committee also regrets very much the loss of one of its valued members of long standing, Mr. G. W. Rear who passed away February 11.

That concludes the report of Committee 7.

President Bond: I want to thank you very sincerely for a very instructive report, instructive in many ways, not only in what it contains but also in the information and the discussion which it brought out.

The committee is excused with the thanks of the Association. (Applause)

Discussion on Impact

(For Report, see pp. 360–362.)

(President Bond presiding.)

Chairman J. B. Hunley (New York Central): Seven subjects were assigned this year, on two of which, No. 4 and No. 5 there is no report. On the other five, progress is reported. Unfortunately, we could not make complete reports because the entire summer was spent in collecting field data, which could not be analyzed for the bulletin this year.

I would like to read these assignments. You will find that, while we made comparatively few tests, there is something in each of these tests that covers most of the subjects.

(Chairman Hunley read the report on Assignment 1.)

Chairman Hunley: Assignment 2 is: Tests of steel spans with ballasted decks, including spans with precast concrete decks and poured-in-place concrete decks; also tests on ballasted decks with timber floors; particular attention to be given to the damping, due to the type of deck and the track ballast. On these spans we were trying to obtain the effect of load joints which was part of Assignment 1, though Assignment 1 includes only open floor bridges. The same procedure was followed.

While the tests have not been analyzed, I might say that the low joint effect is very marked in these spans. When the battered rail joint was replaced by a continuous rail, the effect was very much less; and, in general, the effect both with the battered joint and with no joint was considerably less on the ballasted deck spans.

Report on Assignment 3—Tests of dynamic shear in steel girders and truss spans.

(He then read the report on Assignment 3, following which he read the report on Assignment 6.)

Chairman Hunley: You remember last year the committee reported on the analysis of some tests on open deck spans made on the Pennsylvania, and they were very interesting. It is hoped that the analysis of these tests on this span will give us further information on the ballasted type deck.

(Chairman Hunley then read the report on Assignment 7.)

Chairman Hunley: Following the report of this committee, Mr. Magee is going to show some moving pictures, and I believe one of the reels will show the test of this span, using the oscillator, which may interest you.

That concludes the report of this committee.

President Bond: On behalf of the Association I want to thank Mr. Hunley and his very able committee and staff for compiling what is undoubtedly information of the greatest value. Our thanks to you and your committee. The committee is now excused. (Applause)

Gentlemen, I will ask your attention to what Mr. Magee has to say.

G. M. Magee (Association of American Railroads): During the past year we have taken pictures on various of the research projects that have been going on. These pictures cover the work not only of the Impact committee, which Mr. Hunley has just mentioned, but also some work on locomotive counterbalancing for the Joint Committee on Relation of Track and Equipment, and some measurements made for the Rail committee on service tests of joint bars.

(Mr. Magee showed and explained motion pictures.)

President Bond: We are very glad to have that clear demonstration of the work being done by the research staff under the able direction of Mr. Magee.

Discussion on Water Service, Fire Protection ond Sanitation

(For Report, see pp. 73–105.)

(Vice-President Clarke presiding.)

Chairman B. W. DeGeer (Great Northern): The progress report on Assignment 1—Revision of Manual—will be presented by the chairman of the subcommittee, Mr. E. M. Grime.

E. M. Grime (Northern Pacific): To bring the water service section of the Manual up to date, your committee first offers five minor changes in specifications as follows:

Page 13–27, the heading now reads "Specifications for Steel Substructures for Water Tank". Revise this to read "Specifications for Steel Substructures for *Wood* Water Tanks".

Page 13–37, under "Specifications for Steel Water and Oil Tanks", change the heading to read: "Specifications for *Riveted* Steel Water and Oil Tanks". This is merely to differentiate it from the new specification for welded steel tanks to be offered for adoption at this meeting.

Page 13–37, paragraph 3, weight of water should be changed to read 62½ instead of 63 pounds. Also in the same paragraph, "Wind pressure, acting in any direction", change to read "20 pounds per square foot of vertical projection." This will make it

correspond with the proposed specification for welded steel tanks. On page 74 a typographical error on the last line of paragraph 4 shows 40 and should be corrected to read 20 pounds.

Page 13–38, paragraph 8 of the Manual, change the specification for thickness of flat bottom tanks now reading 5/16 to read ⅜ inch.

I move the adoption of these minor changes.

(The motion was seconded.)

A. M. Knowles (Erie): I am wondering if the committee has considered combining the riveted specifications with the welded specification, making it one, and if there would be any economy in paper and language to make the one specification do for two.

Mr. Grime: The Board of Direction asked for a specification on welded steel tanks, and it was assumed that an addition to what is now in the Manual was desired. There are quite a few differences, so we thought it would be worth while to make a separate specification.

Mr. Knowles: I notice that the American Welding Society has a specification for water tanks which covers both riveted and welded construction. It is very complete and consolidated. It seems to me it might be well for this committee to consider a similar specification and perhaps refer to this Welding Society specification, which covers all phases of welded tanks as well as riveted tanks, as a basis for the specification under consideration.

Mr. Grime: Since we are presenting a specification for welded steel tanks probably that would be a better place to bring it up. Mr. Johnson, chairman of that committee, is entirely familiar with these details.

(Mr. Grime's motion was put to a vote and carried.)

Mr. Grime: During the past few years many refinements have been introduced into the science of boiler water treatment. These call for alterations and additions to what seemed entirely sufficient when written in the Manual ten years ago. We have, therefore, rewritten and brought up to date that part of the matter now in the Manual under the heading "Standard Methods of Water Analysis and Interpretation of Results", as appearing under the sub-head "Field Survey or Rapid Check Tests", page 13–60, and concluded on page 13–64.

The new set-up is shown in the report under the following headings:

(He read the headings on pages 74 to 77, inclusive.)

Mr. Grime: In the lower half of page 77, in the second of the three formulas shown, there appears the exponent "2" after the bracket. This is a typographical error and the figure should be in front of the bracket, making the formula read $2[P - P(BaCl_2)] =$ Carbonate alkalinity in g.p.g. as $CaCO_3$.

(He then referred briefly to the matter on pages 77 to 81, inclusive.)

Mr. Grime: All of these changes in methods as well as the additions and minor corrections have been carefully checked and represent the latest developments in water treating methods.

I therefore move the adoption of all of this material as a substitute for that now appearing in the Manual on pages 13–60 to 13–64, inclusive.

(The motion was seconded, put to a vote and carried.)

Chairman DeGeer: The report on Revision of Manual—Revised Specifications for Cast Iron Pipe—will be presented by Mr. H. F. King, chairman of the special subcommittee which has been appointed to study this subject.

(H. F. King, Erie, read the report and moved the adoption of this revision and the motion was seconded, put to a vote and carried.)

Chairman DeGeer: Progress report on Assignment 2—Cause of and remedy for pitting and corrosion of locomotive boiler tubes and sheets with special reference to status of embrittlement investigations—will be presented by Mr. R. E. Coughlan, chairman of the subcommittee.

(R. E. Coughlan, Chicago & North Western, read the report on assignment 2.)

Chairman DeGeer: The committee has no report on 3—Value of water treatment. We have recommended to the Committee on Outline of Work that this subject be dropped.

The progress report on Assignment 4—Progress being made by federal or state authorities on regulations pertaining to railway sanitation—will be presented by Mr. R. C. Bardwell, in the absence of Mr. H. W. Van Hovenberg, subcommittee chairman.

R. C. Bardwell (Chesapeake & Ohio): The report on Assignment 4 calls attention to two projects being undertaken by the U. S. Public Health Service which affect the railroads.

The first is a revision of the drinking water standards for use on interstate carriers, which was published as an amendment to the Interstate Quarantine Regulations in 1926. The Association of American Railroads has one representative on the advisory committee of the Public Health Service which is considering this matter. The first draft has been considered and is now in process of revision and will be reported on next year.

The second is a code or manual on the sanitation requirements for interstate carriers to be issued by the United States Public Health Service. It appears to be intended that this code or manual will prescribe for various factors affecting sanitation on railroads, including the location of water hydrants and hose, as well as handling, waste disposal, coach yard sanitation, and also dining cars and allied matters.

This is being considered for the railroads by the Joint Committee on Railway Sanitation of the Association of American Railroads on which your Association has three representatives. One conference has already been held with the Public Health officials in Washington, and it is possible some modification may be required in the recommendations made in the Association of American Railroads' Circular M. & S. 194 dated August 2, 1937, which is a working manual based on the report of the AAR Circular M. & S. 133, dated December 21, 1931.

It is the intention of your committee to keep the Association advised of the requirements as developed. It is expected that copies of the second proposed revision will be available at an early date, and copies of these will be supplied to all railroads with requests for suggestions which it is hoped will be furnished promptly.

This report is presented as information.

Chairman DeGeer: The progress report on Assignment 5—Principal activities of the Fire Protection and Insurance Section of the Association of American Railroads—will be presented by Mr. W. A. Radspinner, chairman of the subcommittee.

W. A. Radspinner (Chesapeake & Ohio): Your attention has been called to the statistics covering fires in which the maintenance of way structures and equipment are involved. In view of the scarcity of material to replace such losses, it is important that fire protection be given paramount consideration.

It was the intention of the Fire Protection and Insurance Section to publish a handbook this year, and most of it was ready for the printer. But with the advent of a flood of Civilian Defense pamphlets, circulars and handbooks, it was thought that the distribution of another handbook at this time would be unwise.

It is the recommendation of the Fire Protection and Insurance Section that full-time fire protection inspectors and supervisors be employed by the railroads so that they will be available as railroad representatives in Civilian Defense organizations, and

for the inspection of railroad equipment used in troop movements where kitchen cars with stoves are used.

The nature of the commodities now being transported by rail, and stored in railroad warehouses and piers, justifies the employment of fire protection engineers, capable of supervising the protection of the railroad property and the valuable war materials now being handled by the American railroads.

This report is offered as information.

Chairman DeGeer: Final report on Assignment 6—Use of anti-foam compounds to reduce road blowing—will be presented by Mr. J. P. Hanley, in the absence of Mr. Davidson who is chairman of the subcommittee.

J. P. Hanley (Illinois Central System): During the past ten or twelve years of my experience as a water service man, I have had firsthand opportunities to assist in correcting many troublesome cases of foaming. My experience generally agrees with the information submitted in the report.

On page 85 the report describes the differences between foaming and priming and suggests methods for the correction of each condition. The influence of dissolved and suspended solids is described on page 86 and also the use of corrective compounds made from extracts of the castor bean and various tannins.

While the majority of locomotive water supplies may be used successfully without anti-foam compounds, there still exist many locations and districts where the use of a foaming retarder is economical and greatly increases the boiler water efficiency. These conditions are covered in a summary on page 87 which may be used to good advantage in estimating the relative economy of anti-foam retarders, as compared with resort to increased blow-down, where unusual foaming trouble is experienced.

The report is submitted as information.

Chairman DeGeer: Final report on Assignment 7—Specifications for welded steel tanks for water service, collaborating with Committee 15—Iron and Steel Structures and the American Welding Society—will be presented by Mr. A. W. Johnson, who is chairman of the subcommittee.

A. W. Johnson (Atchison, Topeka & Santa Fe): The railroads have been using riveted steel tanks in water service for approximately 40 years. In the past 8 years, welded steel tanks have gradually come into use. They cost approximately 20 percent less than riveted tanks. Most railroads have plans and specifications for riveted tanks but not for welded tanks.

The specifications prepared by the committee cover plans, materials, structural design, welding practice, accessories and fittings and testing and painting.

We had considerable discussion on the matter of testing the bottom and first side course of a flat bottom steel tank. It is very desirable to provide a good coat of paint on the underside, but unless this is done after welding, the paint will be burned off at the joints.

We took care of this by providing in the specifications that flat bottom tanks have bottom and first side course erected on horses or a tank foundation, and then jacked up and tested with water for leaks, and painted before lowering onto the permanent foundation.

I wish to call your attention to one correction in the specifications. Page 90, paragraph 403, butt welding flat tank bottoms; the specifications as now written provide that no plates will be welded until all plates are in place. To this should be added: "except that such tack welding as is necessary for construction purposes will be permitted."

I move that the specifications be adopted for publication in the Manual.

(The motion was seconded.)

W. C. Swartout (Missouri Pacific): By inference, paragraph 202 limits the welding to electric welding. Is that the intention?

Mr. Johnson: Yes.

Mr. Swartout: Then I am wondering what are the reasons for excluding gas welding, and, if it is the intention, why that is not definitely stated either in paragraph 202 or in another paragraph somewhere under 1. General.

Mr. Johnson: I can only say that we worked with the American Welding Society, and our own Committee 15—Iron and Steel Structures, and it was felt no further description was necessary.

A. M. Knowles (Erie): Doesn't 101 cover that situation clearly? It says, "These specifications apply to the construction of fusion arc welded steel water storage tanks."

Mr. Johnson: We felt that was sufficient, yes.

Mr. Knowles: I would like to call the attention of the Association to the fact that there are no less than three structural steel specifications sponsored by the AREA covering welded construction, i. e., Committee 6, specifications for buildings, and Committee 13, specifications for tanks for railway water service, and Committee 15 for (a) steel railway bridges, (b) turntables. As these are being sponsored by the same Association, it would seem best, for uniformity sake, that the three specifications be similar in all respects regarding welding features, except for some special features not applicable to all three of the specifications.

Committee 15, you will find, recommends, when fusion welding is permitted in steel bridgework, that the current "Specifications for Welded Highway and Railway Bridges—Design Construction and Repairs", adopted by the American Welding Society be used. This specification was first adopted in 1936, revised in 1938 and 1941 and now contains 108 pages of much detail information regarding welding and includes specifications for materials and design for base and weld metal, equipment and processes, workmanship and technique, inspection definitions and welding symbols and qualification of welding procedures and operators. These specifications are designed to be used with general specifications which should control in all other matters that are not affected by the use of the welding process.

I might also say that the American Association of State Highway Officials' specifications for highway bridges which are recommended for use by railroads by this Association also specify that welding shall conform to the American Welding Society's specifications above mentioned.

It is not within the purview of the committee, but I wish to mention the building specification for welded work submitted by the committee this year for consideration at this convention refers to AREA adopted specification for riveted work where it applies and adds additional specifications covering weld metal and other welding features. This would be much simplified by combining the two riveted and welded tank specifications into one and refer to the Welding Society's specifications for buildings for welding features, supplemented with special items of welding work as necessary to apply to building work. That is not for this committee here. I am just mentioning that as information.

Your committee has referred to several items of the American Welding Society's specifications in Articles 202, 401 and 402, but Committee 13 could follow this same procedure as above described for the other committees, with regard to water tanks and refer to the American Welding Society's specifications for "Elevated Steel Water Tanks, Standpipes and Reservoirs of 1941" for all matters pertaining to welding. The American Welding Society's specifications cover both welded and riveted tanks.

Just as a matter of uniformity of procedure and specification, it occurs to me that this might be considered, if the committee hasn't done so.

Mr. Johnson: The committee worked very closely with the American Welding Society in this matter, and we attempted to write a specification for welding steel tanks in water service work that could be used either by railway company forces or contractors.

The committee agreed with the Committee on Outline of Work—not that it made any difference whether we did—that riveted and welded work should be separated, because, in handling that kind of work, if you want a welded job, that is the kind of specification you send out, and if riveted construction is desired you would send out specifications accordingly. We found that railroads did not have a simple specification for welded steel tank work that could be turned over to erectors, and I know that the committee worked with the thought of building up that kind of a specification.

Mr. Knowles: I have no fault to find with the result of the committee's work. It has done a good job and produced a specification covering welded work. My thought was to follow out Mr. Eastman's suggestion this morning, if I may say so, and simplify this specification by referring to the complete specification for welded tanks sponsored by the Welding Society, which covers more phases of the work than this specification does at present.

Mr. Johnson: The committee didn't entirely agree with that thought. It was felt that the American Welding Society is so much better qualified to go into the technical, fine points, that we preferred to condense it, so that steel erectors would have an easier time getting the job done. We do refer to the American Welding Society with the thought that, in case of getting into a split-hair discussion, we would have an authority to lean on.

Mr. Knowles: My only suggestion is to establish uniform practice for the three specifications covering welded work, and to treat them in the same manner.

Mr. Johnson: We don't agree, for one thing, with the testing. We have different ideas about the testing than the American Welding Society, and we have presented our ideas in the specification.

Mr. Knowles: There is one other phase of the specification to which I wish to call to your attention. In Article 201, three grades of steel are specified for use in welded construction, namely ASTM A–7, A–10 and A–78. The ultimate strength and yield point of the three grades are as follows:

Carbon	*Ultimate*	*Yield Point*
A– 7	60,000 to 72,000	33,000
A–10 (Mild Steel)	55,000 to 65,000	30,000
A–78 (Meant primarily for forge welding)	45,000 Grade "A"	24,000 Grade "A"
	50,000 Grade "B"	27,000 Grade "B"

In Article 303 under unit stresses, allowable stress is set forth as 15,000 lb. per sq. in., which would apply to any one of the different grades of steel. I am just wondering if that isn't a waste of material, if we use Grade "A" steel and 15,000-lb. unit stress, when an 18,000-lb. unit stress is considered satisfactory for other uses.

Mr. Johnson: Originally we did have written into the specification a unit stress of 21,000 lb. per sq. in. but we removed that and changed it to 15,000 on the demands of both Mr. Boardman of the American Welding Society, who was at the New York meeting and Mr. Van Ness of Committee 15 who also thought 21,000 was too high. After considerable discussion, we felt that due to the corrosive nature of water, it was perfectly justifiable to use the lower design factor, and we settled on the 15,000 after having had 21,000 in there in the first place, which is the American Petroleum Institute figure.

Mr. Knowles: I have no quarrel with the 15,000 for the low grade steel, with a yield point of 24,000 or 27,000 lb., but it seems foolish to me to allow only 15,000 on a grade of steel with an elastic limit of 33,000 lb. It is not consistent. You can allow different stresses for the A–7, A–10 or the A–78 grades of steel.

Mr. Johnson: What would you say after you had lost 50 percent by corrosion?

Mr. Knowles: You lose bridge steel by corrosion. What I am saying is 15,000 lb. is not consistent for all three grades of steel. If you specify a different allowable stress for each grade, that would be consistent.

Vice-President Clarke: The remarks Mr. Knowles has made have certainly brought out some pertinent points. In view of what he has said, what is the wish of the committee: Do you wish to take this under further advisement, or do you want to proceed with a vote?

Mr. Johnson: We recommend we proceed with the vote.

Mr. Knowles: I would suggest that this specification be presented now as information, so the members will have an opportunity to study it. I think we have not had time to give it the thought it deserves.

Vice-President Clarke: I think that suggestion is, perhaps, a good one. I will suggest to the Association there is a way to make that effective, and that is to defeat the motion. I think, perhaps, it deserves further study. I appreciate the work which the committee has done. We wish to complete our work as rapidly as possible, but we do not want to put in our Manual any matter which is not fully completed and studied.

(Mr. Johnson's motion was then put to a vote and defeated.)

(President Bond presiding.)

Chairman DeGeer: The final report on Assignment 8—Methods for cleaning sewers and underground pipe lines—will be presented by Mr. Grime in the absence of Mr. Wachter who was unable to be present.

Mr. Grime: The report on Assignment No. 8 lists some of the principal causes for decrease in flow capacity, describes the methods employed to remove obstructions or deposits from these pipe lines, and the results obtained thereby.

Two methods, commonly used, are: (1) Mechanical and (2) Chemical. These are described, together with the tools and equipment found best suited to each method.

Improvements developed in recent years have made it practicable and economical to clean most underground pipe lines without removal of major portions. This has made it possible to lower the cost of cleaning appreciably, as well as to reduce the time that the pipe line must be out of service.

Flow capacities of pipe lines which have been observed before and after cleaning are given under Results and Conclusions, as representative of the results which can be secured. These give an indication of the operating economy and other benefits which may be derived by restoring pipe lines to full capacity.

Reference is made to previous report on this subject presented by your committee in the 1921 Proceedings, Vol. 22, pages 413 and 418, and 421 to 426. Improvements since that time, in tools and methods, have made it desirable to bring the subject up to date.

The report is submitted as information.

Chairman DeGeer: The final report on Assignment 9—Practicable size of water columns and supply lines for maximum delivery of water to locomotive tenders—will be presented by Mr. H. E. Silcox, chairman of the subcommittee.

H. E. Silcox (Chesapeake & Ohio): The problem of reducing the time required for water stops has become extremely important to American railroads in connection with their policy of speeding up passenger and freight train schedules. By various methods,

the delivery rates of water columns have been increased to as much as 5,500 gal. per min.

The delivery of a water column depends on:

(a) Size, length and condition of supply line.
(b) Flow head of storage tank above the water column outlet.
(c) Size of storage tank.
(d) Type and design of water column.

Several methods and plans are outlined in this report by which a maximum rate of delivery may be obtained from an existing or new installation. These are: (1) Cleaning the supply lines, (2) increasing the pipe size or, (3) installing an auxiliary water storage tank as close to the point of delivery as possible.

Under present operating conditions it is necessary to deliver water to locomotive tenders with cistern openings ranging from 9 ft. 6 in. to 13 ft. 6 in. above the top of rail. In order to cover this range, the modern water columns are equipped with curved goose neck outlets and telescopic spouts. With the introduction of excessively high water delivery and varied angles of the spout, the force of the water has a tendency to kick the spout out of the cistern opening, thus presenting some hazard in taking water.

In the selection of water column and supply line sizes, no fixed rule can be set as there are too many variable conditions in the individual locations. Each case should be given separate study to obtain the desired results in the most economical manner.

A diagram and six graphic water column delivery charts have been prepared as a guide in making selection of column and supply line to provide the desired water delivery under various flow head conditions and are made a part of this report.

The recommended maximum safe delivery for special water columns serving locomotive tenders of uniform height is considered to be 5,000 to 5,500 gal. per min. With improved water columns serving variable height locomotive tenders without special spout anchoring devices, the maximum safe delivery is considered to be 3,500 to 4,500 gal. per min.

This report is presented as information.

Chairman DeGeer: That completes the report of Committee 13.

President Bond: May I congratulate you and your committee on the very interesting report which has been presented. You and your committee are now thanked and excused.

Discussion on Track

(For Report, see pp. 515–571.)

(Vice-President Clarke presiding.)

Chairman W. G. Arn (Illinois Central): The members of the Track Committee of the American Railway Engineering Association express deep regret occasioned by the death on February 27, 1942, of their fellow-member, Lewis H. Bond, who prior to his retirement May 31, 1941, was chief engineer maintenance of way of the Illinois Central Railroad, and long a member of this committee. His associates feel deeply the loss which they have sustained and will greatly miss the contributions which he has given to this committee in the past.

The first report will be submitted by Mr. Zeeman, chairman of the subcommittee on Revision of Manual.

M. J. T. Zeeman (Atchison, Topeka & Santa Fe): Your committee wishes to submit the following revisions of the Manual:

On pages 5–1, 5–2 and 5–3 are the Specifications for Steel Tie Plates covering two grades of steel, soft grade and the medium grade. It is proposed to eliminate from these specifications the soft grade but retain the medium grade of steel, changing the title to read: "Specifications for Medium-Carbon Steel Tie Plates." There are other revisions in the body of the specifications. There is another proposed revision in the section on Workmanship and Finish which shows the permissible variations in the tie plates. It seems desirable to have the same set of tolerances in the medium-carbon tie plates as are in high carbon plates. Therefore we list the changes under the heading of pages 5–2 and 5–3. This revision affects Sections 401, 402 and 403. I move their adoption.

(The motion was seconded, put to a vote and carried.)

Mr. Zeeman: On pages 5–14.1 and 5–14.2 of the Manual are the specifications for Hot-worked, High-carbon Steel Tie Plates. On page 5–14.1, Section 202 (a) stipulates that the manufacturer shall make an analysis to determine the percentages of carbon and phosphorus and also copper, when copper is specified. In order to show the desired copper content, when it is specified, it is proposed to add in Section 201, following the two lines showing the carbon and phosphorus content, a third line to read: "Copper, when specified, minimum percent . . . 0.20."

Another change is proposed in the same specifications, in the section on Workmanship and Finish, showing the permissible variations in rolling of tie plates. The only revision is in the wording of the tolerances. Now it is given as a variation of so much, and it is proposed to change that to the more definite and specific expression of "over or under."

I might add that this particular section will have exactly the same wording as we have had for the workmanship and finish of the medium-carbon steel tie plates which you have just approved. Therefore, near the bottom of page 517 and the top of page 518, under the heading page 5–14.1 and page 5–14.2, these revisions affecting Sections 201, 401, 402 and 403 are detailed.

I move the adoption of the revisions in this specification.

(The motion was seconded, put to a vote and carried.)

Mr. Zeeman: The next recommended revision is on pages 5–11, 5–12 and 5–13 of the Manual. Those three pages now contain the Specifications for Wrought Iron Tie Plates. It is the opinion of the committee that, on account of the very limited use of wrought iron tie plates, these specifications should be deleted from the Manual. I so move.

(The motion was seconded, put to a vote and carried.)

Mr. Zeeman: The last recommended revision is in the Glossary. On page 29 is the definition of the term "Main track": Since this definition does not correspond to the official designation as given in the Standard Code of the AAR, it is recommended that the present definition be changed to read as follows:

(Mr. Zeeman read the proposed definition of "Main Track.")

Mr. Zeeman: I move the adoption of this definition in the Glossary.

(The motion was seconded, put to a vote and carried.)

Chairman Arn: The next assignment—Plans and specifications for track tools and recommended minimum limits for reclaimed tools. Mr. Roller, chairman of this subcommittee, will present the report.

W. L. Roller (Chesapeake & Ohio): This report is composed of two parts. Due to certain changes in practice and the reduction of grades in hickory handles, it is deemed advisable to adopt a new specification. Heretofore we have incorporated in our specifications the recommendations of the Bureau of Standards, Division of Simplified Practice. We have attempted in this case to elaborate and extend the specifications on pages 519, 520 and 521 to meet the present conditions.

I move the removal of our specifications for hickory handles as now included in the Manual and the substitution of these here shown.

(The motion was seconded, put to a vote and carried.)

Mr. Roller: In the Proceedings for 1941 this committee offered for information certain data on limits of wear for track tools in collaboration with the Purchases and Stores Committee 3–A. It was not felt, in offering this final report this year, that it was incumbent upon the committee to report on specifications for these repairs but merely to follow the outline of work as assigned. Therefore, we submit a list of tools numbering from 1 to 21, inclusive, which appeared in the Proceedings of last year, with dash lines indicating the limits of wear that are recommended.

I move the adoption of the revision of these plans as recommended practice.

(The motion was seconded, put to a vote and carried.)

Chairman Arn: The next subject is: Plans for switches, frogs, crossings, spring and slip switches. This year, after three years' work, the subcommittee has practically completed the revision of the portfolio of track plans and, because of the action being taken by the War Production Board to limit the number of standards and specifications, it is fortunate that we have progressed this far.

Mr. Caruthers is chairman of this subcommittee and will submit the report.

E. W. Caruthers (Pennsylvania): The new plans were submitted in Bulletins 427 and 430. The work is all summarized on pages 522 to 537, inclusive, and the committee wishes to recommend the adoption of Plans 122–42, 124–42, 126–42, 128–42, 190–42 and 220–42. I so move.

(The motion was seconded, put to a vote and carried.)

Mr. Caruthers: I further would like to move the adoption of 390–42, 407–42, 408–42, 490–42, which cover spring rail frogs and bolted rigid frogs.

(The motion was seconded, put to a vote and carried.)

Mr. Caruthers: I further move the adoption of Plans 690–42 and 691–42, which cover railbound and solid manganese frogs.

(The motion was seconded, put to a vote and carried.)

Mr. Caruthers: I further move the adoption of Plans 700–B–42, 700–D–42, 719–42, 721–34, 813–42, 814–42, 820–35, 821–42, 835–42 and 836–42, which cover details for crossings, tie layouts for crossings, foundations for crossings, double slip switches and movable point crossings.

(The motion was seconded, put to a vote and carried.)

Mr. Caruthers: I wish further to move that Plans 1010–42 and 1011–42 be adopted as recommended practice, showing permissible variations in completed frogs and switches.

(The motion was seconded, put to a vote and carried.)

Mr. Caruthers: Adopting the plans which have just been referred to, makes it necessary to remove from the book of plans a number of the more or less obsolete plans. I move deletion of the following list of plans.

(Mr. Caruthers then read the list of plans for withdrawal, appearing on page 524.)

(The motion was seconded, put to a vote and carried.)

Mr. Caruthers: I now move the adoption of Appendix A–42 which is found on pages 525 to 539, inclusive. These specifications cover the necessary details for material, workmanship, inspection, applicable to the plans which have now been adopted.

There is one correction I would like to call attention to and that is found on page 528, paragraph 103. The last sentence should read: "All 'A' and 'X rayls' are excluded."

With that revision, I would like to move the adoption of Appendix A–42 covering specifications for special track work.

(The motion was seconded, put to a vote and carried.)

Mr. Caruthers: I also move the deletion of Appendix A, revised in 1934 and the portion adopted in 1938, as that is now superseded by the specification which has just been adopted.

(The motion was seconded, put to a vote and carried.)

Vice-President Clarke: I want to say to the Association that this subcommittee has been working long and hard on this most important assignment. It is to be complimented. The Association is to be congratulated on the work that has been done, and we are most fortunate that this job has been completed.

Chairman Arn: The War Production Board appointed a committee on specifications to do what could be done in reducing the number of specifications and the number of plans, and your Board assigned to this committee a review of this portfolio which has just been completed with recommendations. It was found that very few of these could be eliminated. A subcommittee of which Mr. Caruthers is chairman, has given this study and prepared a report which was reviewed and approved by the Track committee only yesterday.

Mr. Caruthers will summarize that now.

Mr. Caruthers: Following the instructions received from the chairman of the Track committee, a small special subcommittee met on Monday and made a thorough review of all of the plans that have now been adopted and represent the current book of trackwork plans, having in mind, in making this review, simplification, if any, that could be effected as a war measure, avoiding duplication, and, particularly, the possible conservation of manganese, an essential war material.

After going over these plans, the committee found that the only plans which could be recommended as being suspended for the period of the war were, Plans 220–42, 503–40, 773–40, 774–41, 775–41, 983–35; and the portion of Plan 821–42 showing rail bound and solid manganese steel knuckle rails. In addition it is recommended that the title on Plan 772–40 be revised to read "Solid manganese steel crossings, angles below 60 deg. to 45 deg."

The plans that have just been mentioned primarily would remove a duplication in the series of crossing plans where both solid cast and rail bound construction are now recommended. The committee, in this review, felt that that was not necessary and has so recommended.

As I understand the situation, no action is necessary on the part of the Association as the standing committees have been authorized to make certain suspensions in the recommended practice of the Association. This is, therefore, presented as information.

Vice-President Clarke: You understand this is merely information which Mr. Caruthers is presenting, in that we have been asked during the emergency to conserve critical material wherever possible, of which manganese is or may become one, and we have been asked to standardize and simplify plans, wherever possible, not with the intention that the railway industry would be seriously curtailed but that the war effort might be advanced. By action of the Board, it has been arranged that the various committees, by letter ballot, can make a temporary change in a plan, or specification that is in the form of a rider, without affecting the Manual, and which will be effective for the period of the emergency only.

This is now being presented to you in line with that action and as information.

Mr. Caruthers: In addition, the subcommittee concluded its report to the standing committee with the following:

"From the standpoint of the greatest conservation of both labor and essential material, the committee recommends that, for the period of the war, the established trackwork standards of the individual railroads shall be continued, and where no such standards are established, material in accordance with the AREA portfolio of trackwork plans shall be used."

Chairman Arn: The next assignment—Photoelastic study of stresses in tie plates. Mr. Perlman, chairman of the subcommittee, will present this report.

A. E. Perlman (Denver & Rio Grande Western): In order to get the most economical distribution of metal in tie plates and in order to have it where it would do the most good, a study was made by the subcommittee both in the laboratory and in the field to determine the stresses which were encountered in tie plates.

In the laboratory Mr. Walter Leaf, research technician, made photoelastic studies and, in the field, Mr. Magee with a party from the AAR, and Mr. McBrian of the Rio Grande used strain gages to determine the stresses actually encountered in service. These methods are complementary; the field studies do not always disclose the maximum stresses because the strain gages may not be located at the point where maximum stress occurs; the laboratory may not simulate the exact conditions which are found in the field.

Twelve different loading conditions were used in the laboratory in making these photoelastic studies which are listed in the report. The reason for this was that several factors influence the design of tie plates as listed on page 539; the fit between rail base and plate, the fit between plate and tie, the design of rail base, the design of tie plate, the elastic modulus and uniformity of the tie, and the direction and amount of the applied load.

As brought out in the report, direct compression and shear in the plates supported uniformly by a perfectly rigid tie would be very low and would be a simple function of the bearing area between rail and plate and the applied load. But bending moment is the factor which gives the greatest stresses. Therefore, these 12 studies were made, and the stress distribution diagram is shown on Fig. 1 on page 541. These stresses are the tension measured along the bottom of the plate.

The field stress measurements were made in July, 1941, near Price, Utah, and pages 543 and 544 show the stress diagrams. The results were very interesting but not wholly conclusive, because the tests were made in a very short time and were not sufficiently extensive.

It was found, however, that the stress in a tie plate is not merely a function of the applied load and thickness of the plate, because a thin bar deflects more under a load than a thick one, thus removing the greatest proportion of its length from tie reaction, and consequently behaving as though supported on a shorter span.

There are a number of field determinations yet to be made. The effect of curvature on the direction of the applied load should be studied; and although the field work to date has been rather brief, it has indicated, together with the photoelastic work, that the Rio Grande tie plate weighing about 15 lb. is heavier than it need be.

We feel that we have been using too much metal in the tie plate and that, by proper design, a very substantial amount of metal could be saved and yet accomplish the same results. This is merely a progress report, and we hope to go on with the study next year and reach a final conclusion.

Chairman Arn: The next assignment is: Design of tie plates for RE rail sections as developed. Major Macomb, chairman of this subcommittee, will submit the report.

J. de N. Macomb (Inland Steel Company): The preliminary report is printed on page 547. Unfortunately, the designs were not completed in time to appear in Bulletin 430 and a supplemental report has been distributed. This was prepared at such a very late hour that it was sent direct to the secretary and it has only just come from the printer.

(Mr. Macomb then read the supplemental report on Assignment 6 which follows:)

Supplemental Report on Assignment 6

Design of Tie Plates for RE Rail Sections as Developed

Collaborating with Committees 3—Ties, and 4—Rail

J. de N. Macomb (chairman, subcommittee), L. L. Adams, W. S. Boyce, E. W. Caruthers, H. R. Clarke, O. U. Cook, J. A. Ellis, H. F. Fifield, C. T. Jackson, J. A. Reed, G. L. Sitton, G. M. Strachan.

The Manual contains among others the following plans for tie plates with inclined ends:

Plan No 2—11-Inch Tie Plate, for Use with 112-Pound RE Rail.
Plan No. 3—12-Inch Tie Plate, for Use with 131-Pound RE Rail.,

In response to the demand for larger tie plates with inclined ends, a canvass of the principal railroads was made under date of May 19, 1941. This canvass indicates that 14 railroads favor the preparation of plans for tie plates larger than those referred to above, and that

a 12-in. section for use with 112-lb. RE rail, and
a 14-in. section for use with 131-lb. RE rail

would most nearly meet the requirements of the railroads concerned.

In view of the preceding, plans designated "A" and "B", respectively, have been prepared.

The thicknesses under the rail seat are somewhat less in comparison with the lengths outside the shoulders than those in the plans now in the Manual.

The eccentricity is ¼-in., the same as in Plans Nos. 4 and 5.

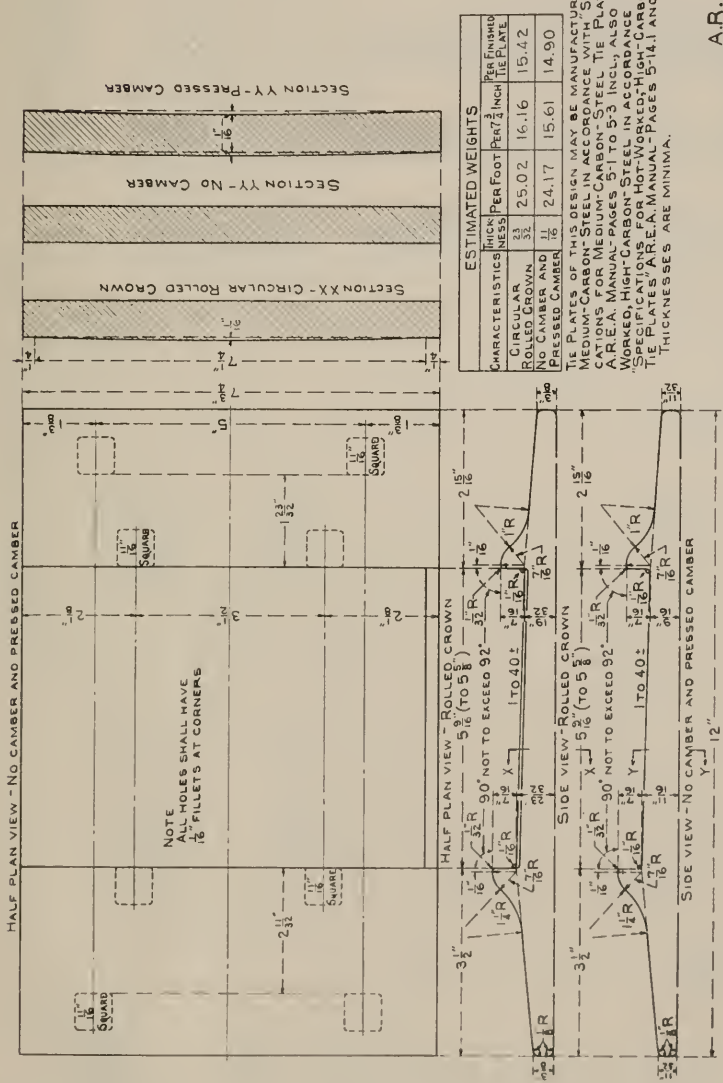
The spike holes at each end of the tie plate are located from the *near* shoulder, instead of from the *high* shoulder, which practice was followed in the plans now in the Manual.

The spike holes along the edges of the base of rail are $\frac{11}{16}$ in. square, the same as the holes for the "hold down" spikes.

The "hold down" spike holes in both tie plates are so located that the tie boring (for the "hold down" spikes) will be the same. This was also true of plans Nos. 2 and 3.

Otherwise the details of Plans "A" and "B" are similar to those of plans of inclined-end tie plates now in the Manual.

These plans are offered as information.

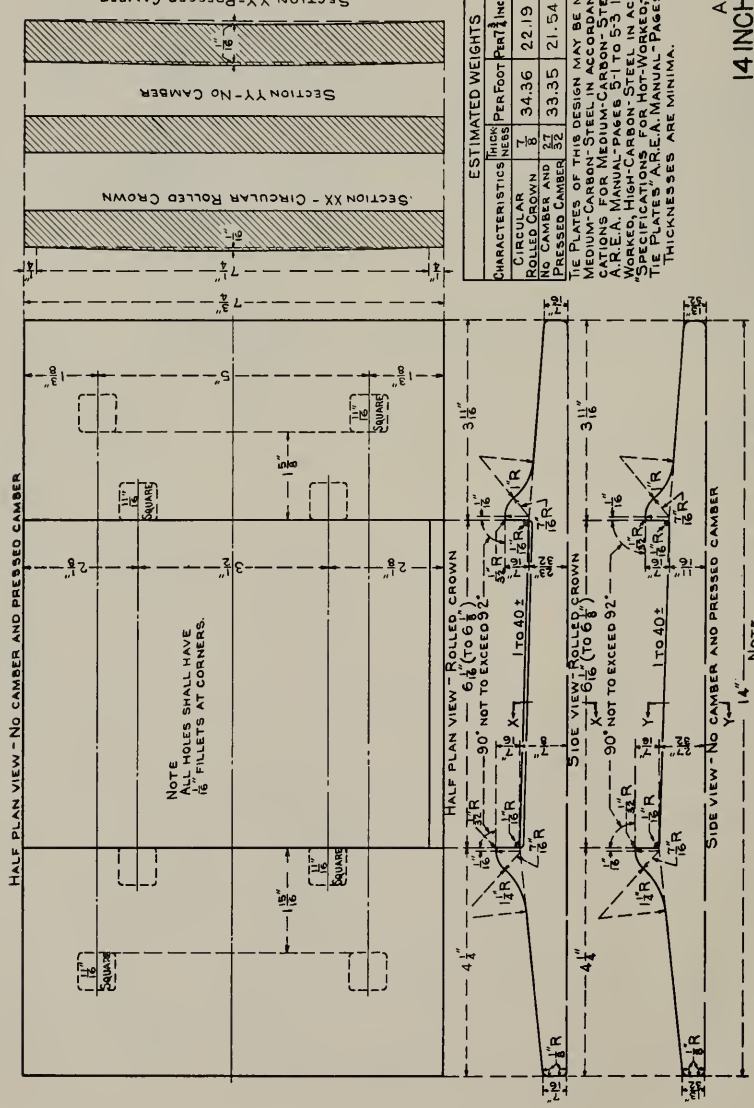


ESTIMATED WEIGHTS

CHARACTERISTICS	THICKNESS	PER FOOT	PER 7 3/4 INCH	PER FINISHED TIE PLATE
CIRCULAR ROLLED CROWN	23/32	25.02	16.16	15.42
NO CAMBER AND PRESSED CAMBER	11/16	24.17	15.61	14.90

TIE PLATES OF THIS DESIGN MAY BE MANUFACTURED IN MEDIUM-CARBON-STEEL IN ACCORDANCE WITH SPECIFICATIONS FOR MEDIUM-CARBON-STEEL TIE PLATES" A.R.E.A. MANUAL-PAGES 5-1 TO 5-3 INCL., ALSO IN HOT-WORKED, HIGH-CARBON-STEEL IN ACCORDANCE WITH SPECIFICATIONS FOR HOT-WORKED, HIGH-CARBON-STEEL TIE PLATES" A.R.E.A. MANUAL-PAGES 5-14.1 AND 5-14.2. THICKNESSES ARE MINIMA.

A.R.E.A.
12 INCH TIE PLATE
FOR USE WITH 112 LB. R.E. RAIL
PLAN A



Estimated Weights			
Characteristics	Thickness	Per Foot	Per 3/4 Inch Finished Tie Plate
Circular Rolled Crown	7/8	34.36	22.19
No Camber and Pressed Camber	27/32	33.35	21.54
			20.66

Tie Plates of this design may be manufactured in Medium-Carbon-Steel in accordance with "Specifications for Medium-Carbon-Steel Tie Plates," A.R.E.A. Manual-Pages 5-1 to 5-3 Incl., also in Hot-Worked, High-Carbon-Steel in accordance with "Specifications for Hot-Worked, High-Carbon-Steel Tie Plates" A.R.E.A. Manual-Pages 5-14.1 and 5-14.2. Thicknesses are minima.

A.R.E.A.
14 Inch Tie Plate
For Use With 131 Lb. R.E. Rail
Plan B

Vice-President Clarke: The plans have been prepared, as the chairman explained, in answer to a request of some roads that plans be made available for larger tie plates than those shown in any plans the Association had so far provided, and they have been prepared in line with that request and are being offered as information. You will note that, in general, they follow the same principles as the other plans which we have adopted. That is true, is it not?

Mr. Macomb: That is correct, as explained in this report.

J. M. Farrin (Illinois Central): I notice the plans show camber as an alternative design in these tie plates. A number of places on the Illinois Central have been investigated; and it has been found that, wherever a tie plate was cambered, only that portion that represented the highest part of the camber showed any evidence of rail contact; the rest of the plate was rusted.

So I have just been wondering what is the necessity for cambering. I think that that phase of tie plate design ought to be investigated, because it costs a little money to put that camber in.

Mr. Macomb: The majority of the tie plate plans in the Manual show the tie plate crowned, cambered or without either crown or camber.

At the present time a great many crowned tie plates are used. These plans are additional to those now in the Manual, simply carrying the series a little farther.

Possibly, as the earlier plans have now been in the Manual for sometime, a review might be desirable, and one of the features that should be considered, is whether the tie plates with the crown should be continued in the Manual.

Mr. Farrin: That would be very well to look into. There is another question: Why is it necessary to have a bigger and heavier plate with a heavier rail, when the function of the heavier rail is really to give you a less load on a tie plate? I think that that question has never been thoroughly investigated.

Mr. Macomb: You are correct, the heavier the rail, other conditions being the same, the stronger and stiffer the rail, the farther the load will be distributed over more ties and, therefore, the smaller tie plate would be justified.

However, I think we must look at this from the standpoint of varying standards. We assume that one railroad, having light traffic conditions, will, perhaps for economic reasons, adopt a light standard construction, if you like, a 90-lb. rail with 10½-in. tie plate. Another road, having very heavy traffic conditions, adopts perhaps a 131-lb. rail with 14-in. tie plate. There certainly is a relationship, and the relationship is that the entire structure should increase in size and strength together. But we have cases at the present time where the same traffic—and this is possibly what you had in mind—in moving over a railroad system, moves over different weights of rail and will do so for a period of 15 years, or so. Manifestly, you should have at least as large a tie plate under the light rails as you would have under the heavy. For that reason it might be desirable in another year, in this particular case, to add a 14-in. section, if you like, for use with the 112-lb. as well as for the 131-lb. rail. Does that answer your question?

Mr. Farrin: The answer is "yes" but it just seems to me that there ought to be some statement as to the desirability of the different size tie plates based on density of traffic, just at what point it ought to be changed from one size to another.

Mr. Macomb: That is a subject that could be assigned to the committee, and the committee would be very glad to consider it.

Mr. Farrin: There is another question, and that is the question of the eccentricity in a tie plate. It just seems to me that what has been done up to the present time is to guess at it, using a cut and try method. It does seem that tie plates have been used long enough so that some information ought to be available as to just about

what this eccentricity ought to be for the different sizes of tie plates. I know on our railroad a great many of the division engineers don't want any eccentricity at all. I don't know which is right. Theoretically, eccentricity is required; practically, whether it is required or not, I don't know. It does seem that that ought to be investigated as well as can be and some information presented.

Mr. Macomb: That matter of eccentricity, perhaps, causes more concern than any other feature of the tie plate. We have in the committee those who advocate practically no eccentricity, which you have just expressed, and those who advocate at least ½ in. The sections shown in these drawings have an eccentricity of ¼ in. Most of the other inclined end sections in the Manual have ⅜. Two of the flat-end sections, Nos. 4 and 5, the 12-in. for use with the 112-lb. rail and the 13-in. for use with the 131-lb. rail have ¼-in. eccentricity.

Apparently the desirable eccentricity depends upon or is determined by, the character of the railroad. A tie plate with a certain eccentricity would be more desirable on one railroad than on another. What we have tried to do was to use characteristics that were generally applicable to the average railroad, but this matter of eccentricity is far from settled and is a subject the study of which could well be continued.

As you say, there are certainly enough tie plates of various eccentricities in track and they have been there long enough so that a study of their performance should give us valuable information as to what the most desirable eccentricity is.

Mr. Farrin: There is another question I would like to bring up. In the cross section you show a square shoulder on each end of the tie plate, longitudinal of the rail. If camber is necessary, you certainly shouldn't have a square shoulder because the tendency would be, as the rail bent down, to nick the base of the rail. It ought to be chamfered off.

Mr. Macomb: The reason for that is that, in rolling a long bar which will be cut up into tie plates, with crowns, the crowns are separated by flat portions, say ½ in. wide. This is provided for the purpose of shearing the consecutive tie plates from one another. There must be a little latitude for the operation of shearing. If you had these successive crowns exactly meeting at a line and the shear knife didn't strike that line, instead of having a flat place you would have a portion of the next slope, and your condition would be worse than it is now. It is simply a detail. Where the crown is only 1/16 in. and this flat place is only ¼ in. wide (on each tie plate) it can have very little undesirable effect such as you speak of.

Mr. Farrin: I notice that same condition is shown for the flat plate as well as for the cambered plate. It does seem as if that end ought to be chamfered a little. You have the same condition in the joint bar at the end of the rail. You nick the joint bar and the first thing you know, your joint bar breaks.

Mr. Macomb: May I ask if what you have in mind is to advocate what might be called a "beveled crown?" That is being used by several western railroads where the middle portion of the rail seat of the tie plate for some 5 or 5½ in. is flat and then slopes down 1/16 in., or whatever the thickness of the crown is, and terminates in perhaps a ¼-in. flat place. That perhaps would give the effect that you have in mind.

Mr. Farrin: I think it would.

Mr. Macomb: That was shown in some of our studies but it is used by only a few railroads at the present time and so far has not been incorporated in the Association's plans. That, again, is a feature that perhaps should be considered further by the committee.

Vice-President Clarke: Might I suggest that these plans are being submitted as information and for the study and consideration of the members. I am very sure it

would be greatly appreciated by the committee if you will submit the very pertinent and worth while suggestions which you have made to them, in writing, and they will certainly take cognizance of them and be happy to have them.

C. J. Geyer (Chesapeake & Ohio): It is my recollection that the work of this subcommittee, which was started several years ago, was primarily to reduce the number of designs of tie plates. I believe there are in the neighborhood of 100 different sections of plates for which the mills had rolls. To reduce the need for all these rolls, to standardize on fewer designs, was one of the main purposes of this subcommittee. There were designed, and approved by the Association, the five plates that are now in the Manual. They have been on the approved list for several years past. Before changing those designs, I suggest the committee find out if the roads now requesting larger plates are using ones as large as the plates already in the Manual on the approved designs, and that the committee find out whether those plates that are now approved are doing the job, and then proceed with the change in the design if they find they are not. I suggest that in the interest of keeping down the number and necessity for additional rolls in the mills and increased costs for so many different designs.

Mr. Macomb: I am sure the committee will be very glad to consider that suggestion.

Vice-President Clarke: Was such a canvass not made, and did you not find certain roads desired larger plates?

Mr. Macomb: Yes, we did.

Vice-President Clarke: Was it not felt that each individual road that might want a larger tie plate than we have a plan for would design their own plate, and, consequently, there might be ten or a dozen designs of plates which each individual road would use, resulting in a multiplicity of rolls, just as Mr. Geyer has suggested, and the purpose of this assignment and the work of the subcommittee was to obviate that very thing?

Mr. Macomb: That is quite right.

Mr. Geyer: I was suggesting that he find out if these roads asking for larger tie plates would not first try the ones that are already larger than the ones they have and are using, to see if these now in the Manual won't meet their requirements.

Mr. Macomb: I might say, in connection with that, there seems to be a desire on the part of certain roads to use a larger tie plate with inclined ends. These two plans which are offered in this report do not add to the number of tie plate designs we have, as far as size is concerned. They do give us inclined end tie plates where we now have flat end. There is a conservation feature there. If one is not going to use a screw spike, he will not care to use the flat end design which requires more steel.

That, I think, is the occasion for these particular designs.

Mr. Farrin: I think it would be very well for this committee, also, to investigate and give some information on how far a tie plate should be allowed to embed itself in the tie.

Some little time ago, during this last summer, I had occasion to make some investigation and found that on track bearing 20,000,000 tons of traffic a year, with 11-in. tie plate, in four years' time, on the class of ties that were being used there, that tie plate embedded itself about 1/16-in. into the tie, and it was a little deeper in one end of the tie plate than it was on the other, that is the transverse of the track. I think, as I remember now, it was probably 1/16-in. deep on one end of the tie plate and maybe ⅛ on the other, showing eccentricity must have had some effect.

In addition to that, some light ought to be thrown on the question as to just how far the tie plate ought to be allowed to embed itself into the tie over the life of the tie under the track.

Mr. Macomb: I assume that assignment can go jointly to the Committees on Ties and Track because, certainly, the Committee on Ties would be interested in it. That really gets down to the point of the proper tie plate or the proper dimensions of tie plate for use under various traffic conditions, and with various ties. That is a subject that could also be considered.

Chairman Arn: The next assignment is: Practicability of using "reflex" units for switch lamps and targets, collaborating with Committee 10—Signals and Interlocking. Mr. L. L. Adams, chairman of the subcommittee, will submit the report.

L. L. Adams (Louisville & Nashville): Several reports have been made on this assignment in the past, first in 1933, at which time only 3 roads were using the reflex units. In '39 the number had increased to 13, with a total of 4,588 units in service.

We sent out a questionnaire last year to 78 roads; and 25 replied that they were using reflex units rather extensively, and a total of 10,754 units were in service. In the questionnaire we tried to determine what the various roads thought of the reflex units. There was a wide variation in opinions, ranging all the way from condemnation up to enthusiasm. The replies on the question of saving have been rather uniform throughout the various years; and the estimated saving on those in service at the present time is somewhat in excess of $157,000 a year, which I think is worthy of consideration.

Since this report was published in December, two questions have arisen—one concerning blackouts, and the other, conservation of oil. These reflex units would be a big help in solving both of those questions.

We offer this as information.

Chairman Arn: The next assignment is: Welding of manganese castings in special trackwork. Mr. Bishop, chairman of the subcommittee, will submit the report.

F. J. Bishop (Toledo Terminal): The report on welding of manganese castings is very brief. The first paragraph summarizes previous reports of the subcommittee, for anyone who is interested. The second paragraph on page 550 gives a résumé or some information on the status of our 24 test frogs which have been in service on the Milwaukee since 1939. These frogs have worn so well that we probably will not be able to make any test welds until sometime this spring or summer.

The report is submitted as information.

Chairman Arn: The next report—Bolt tension necessary for proper supporting of rail joints—will be submitted by Mr. C. W. Breed, chairman of the subcommittee.

C. W. Breed (Chicago, Burlington & Quincy): Results are reported on the measurements taken during the last year to determine loss in bolt tension and joint bar wear under traffic on the test installations on the Milwaukee, the Burlington, the Rio Grande, the Erie and the Pennsylvania.

As stated in last year's report, the committee is endeavoring to discover the relation between joint bar wear and tonnage carried, and to relate this to the resultant loss in bolt tension; giving consideration to the size of the rail and the various types of spring washers that may be used. The committee has not attempted to draw conclusions as yet, because in all test installations the rail was either new or practically new; and it was desired to see what effect increased wear of rail and bars might have upon bolt tension.

On the Milwaukee installation with 112-lb. rail and no spring washers, the bolts with 8,000 to 12,000 lb. initial tension performed satisfactorily except that too large a proportion, about 15 percent, became loose during the year. The bolts with 15,000 to 20,000 lb. tension did better, there being only 6 percent loose during the year's time. It will be noted that with no spring washers in use on bolts in this test, a greater loss of tension occurred during the year's period than during the previous year.

On the Burlington installation, the average rate of bolt tension loss is now quite low, generally averaging from 300 to 500 lb. loss per month. However, loss in tension varies widely at different joints and at different bolts in the same joint. For the joints with initial tension approximating 15,000 lb., about 10 percent of the bolts were loose at the end of the 18 months' period test. With an initial tension approximating 30,000 lb., less than one percent of the bolts became loose during the same period. It will be noted that during the period after April 1940, the head contact bars have shown a relatively greater loss of bolt tension than the head free bars, although in the preceding period this was not evident. The reason for this is that head contact bars show greater inward movement after April 1940.

On the Rio Grande test installation during the 9 months since all bolts were replaced, the average rate of bolt tension loss is quite low, only about 500 lb. per month. Initial applied tension was about 25,000 lb., and no bolts became loose during the 9 months' test period. As in other tests, the loss was not uniform at all joints. Some joints lost much more than 500 lb. per month, and others lost very little or nothing. Observation indicated that those joints showing least expansion and contraction movement of the rail ends had the least bolt tension loss.

The average rate of loss in bolt tension on the Pennsylvania test averaged 500 lb. per month, which is about the same as on the other tests, and yet the traffic density on the Pennsylvania is very much greater.

These results indicate that traffic density is not the major factor in producing loss in bolt tension. The average applied tension on the Pennsylvania test was 17,000 lb., and no bolts were found loose in the 4 months' test period. This is of particular interest when it is noted that the bolts on this test were equipped with finger-free nuts.

On the Erie test, the applied tension was about 15,000 lb.; and in the 14 months' test period, no bolts became entirely loose, although in a few very little tension remained. The average rate of bolt tension loss was also quite low, approximately 300 lb. per month.

The committee believes that its 1942 work will permit rather definite conclusions on the assignment. This is offered for information.

Chairman Arn: There is nothing to present this year on Assignment 10—Lubrication of rail on curves.

The next assignment is: Prevention of damage due to brine drippings on track and structures. Mr. Magee, chairman of the subcommittee, will submit the report.

G. M. Magee (Association of American Railroads): In previous reports the committee has described laboratory tests to determine whether any inhibitor could be added to the salt used in icing refrigerator cars, which would neutralize or retard the corrosive effects of the brine on the track and bridges.

Good results were indicated in these laboratory tests by using sodium dichromate neutralized with soda ash as the inhibitor. It was desired to check this in some manner by an actual track test. No method appeared practical for use in refrigerator cars in actual service. It was finally decided to spray a short section of rail and tie plates daily for a 90-day period with salt solution and compare this with a similar section treated in like manner, with salt solution containing inhibitor.

This report gives the results of two tests, one made by the Milwaukee Railroad and the other by the Rio Grande. The results check the laboratory work reasonably well, indicating a good protection from the use of the inhibitor. We have attempted to get the inhibitor applied in refrigerator cars in actual service for a year's test period in order to study the protective effects upon corrosion of the car itself. However, we encountered objection from the shippers on the ground of possible contamination of

the car contents from the inhibitor, which is toxic. The matter was taken up with the Medical Section of the AAR, and it was suggested that we devise means of applying the inhibitor which would insure against any contamination of the car contents. The work is now being continued with that objective in view. The report is presented as information.

Chairman Arn: In connection with that, I might state that we have a letter from Mr. Barton Wheelwright, chief engineer of the Central Region of the Canadian National in which he proposes a new mixture, which had not been suggested when the committee made a previous canvass. He, like men on most of the other roads, found that the paint on bridges was ineffective; and that a mixture of ordinary black oil with about 20 percent of raw linseed oil has given better results than anything else that had been tried heretofore.

The next assignment is: Specifications for high-carbon steel track spikes. It was our intention to submit this report as information; but after our contact with the War Production Board through the National Emergency Steel Specifications Committee, it was found advisable to present the specifications for adoption because a number of roads are using the high-carbon spikes.

Mr. Martin, subcommittee chairman, will submit the report.

E. E. Martin (Pennsylvania): The committee desires to direct your attention to a slight error in printing which has occurred, on page 571 under Section 401. Marking—where reference is made to the letters "OU" when copper is specified. The correct designation for the presence of copper will be the chemical symbol "CU" generally used to designate the presence of copper.

I move the adoption of the specifications for printing in the Manual.

(The motion was seconded, put to a vote and carried.)

Vice-President Clarke: This is one of our most important and, as I have taken occasion to say before because I am a member of the committee, one of the most hard-working committees we have. It has presented an excellent report, and it is excused with our thanks.

MONOGRAPH

Influence of the Fatigue Strength of Structural Members Upon the Design of Steel Bridges

By W. M. Wilson

Research Professor of Structural Engineering,
University of Illinois

1. Introduction

The possibility that a structural steel member might fail in fatigue had not been generally considered in the design of bridges until recent years. European tests of small fabricated specimens showed that failure could be produced by a large number of repetitions of a load much smaller than the static load required to break the same specimen. Reports of failures of bridge members in service began to accumulate[1] and it was noted that these failures were similar to fatigue failures and not at all like static failures. Moreover, tests of small machined specimens with large stress raisers, gave values for the fatigue strength very much lower than values obtained from similar specimens without stress raisers. This indicated that the geometry of the specimen might have as great an effect upon its fatigue strength as the material from which it was made and that the fatigue test of small machined specimens, while satisfactory as an indication of the fatigue strength of machined parts, had little, if any, value as an indication of the fatigue strength of fabricated structural members. The situation indicated clearly that fatigue tests of fabricated joints, as large as it was feasible to test, would have to be made before the importance of fatigue as an element in structural design could be evaluated.

2. Description of Fatigue Tests

Two investigations of the fatigue strength of fabricated joints of structural steel members have been made at the University of Illinois. The first was an investigation to determine the fatigue strength of riveted joints[2]; and the second was an investigation of the fatigue strength of butt welds in structural steel plates.[3]

The tests were made in lever-type machines that produced an axial stress in the specimen. The machines, which had a rated capacity of 200,000 lb., were adjustable so as to give any desired ratio of minimum to maximum stress from a complete reversal to a pulsating stress in either tension or compression. They ran at a speed of approximately 180 r.p.m. and operated day and night without an attendant. The general features of the machines are shown in Fig. 1 and details of typical specimens are shown in Figs. 2 and 3.

In order to define the fatigue strength of a structural member it is necessary (1) to state the ratio of the minimum to the maximum stress in the stress cycle and (2) to state the number of cycles for failure.

Most tests on small machined specimens have been made on a cycle in which the stress was completely reversed and the object of the tests was to determine the maximum stress to which the specimen could be subjected an infinite number of times without failure. Few structural members are subjected to a complete reversal of stress; instead, most members for which the fatigue strength must be considered are subjected to a

[1] AREA Bulletin 415, p. 412. Report of subcommittee of Committee 15 on Progress in Design of Steel Bridge Details. B. R. Leffler, chairman.

[2] University of Illinois Engineering Experiment Station Bulletin No. 302. The bulletins referred to hereafter in this article are University of Illinois Engineering Experiment Station bulletins.

[3] Bulletins 310 and 327.

pulsating stress, that is, the stress varies from a high to a lower tension or from a high to a lower compression. A few members are subjected to a stress that varies from a high tension to a low compression or from a high compression to a low tension. Likewise, few structural members are subjected to a number of cycles that even remotely approaches infinity. The structural engineer is interested in the stress that will produce failure at a few hundred thousand or, at the most, a few million repetitions.

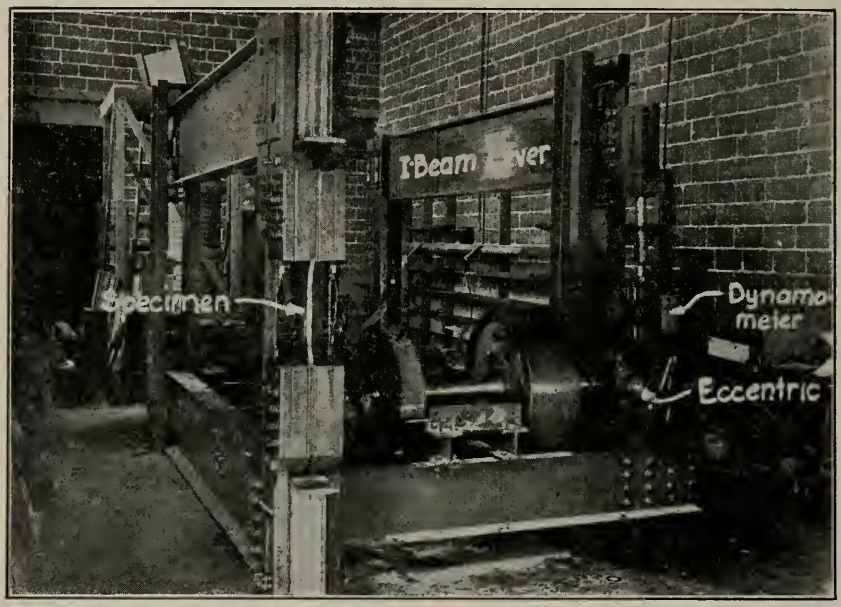


Fig. 1.—Duplex Fatigue Machine.

In the investigations at the University of Illinois, three ranges of minimum to maximum stresses were used:

(1) from a given tensile stress to an equal compressive stress;

(2) from zero stress to some given tensile stress;

(3) from a given tensile stress to a tensile stress one-half as great.

Likewise, in the University of Illinois investigations, the maximum stress in the stress cycle was chosen, as nearly as it was possible to determine in advance, so that failure would occur at either 100,000 or 2,000,000 cycles. Because it was impossible to have failure occur at a pre-determined number of cycles, the value of the fatigue strength corresponding to failure at these numbers of cycles were computed from the actual stress and the actual number of cycles for failure by the use of the empirical equation[4] $F = S\left(\frac{n}{N}\right)^K$, in which F is the fatigue strength corresponding to failure at N cycles, S and n are the actual stress in the stress cycle and the actual number of cycles for failure and K is an experimental constant depending upon the stress-raising characteristic

[4] For a discussion of this equation, see Bulletin 302, p. 111 and Bulletin 327, pp. 14 and 19.

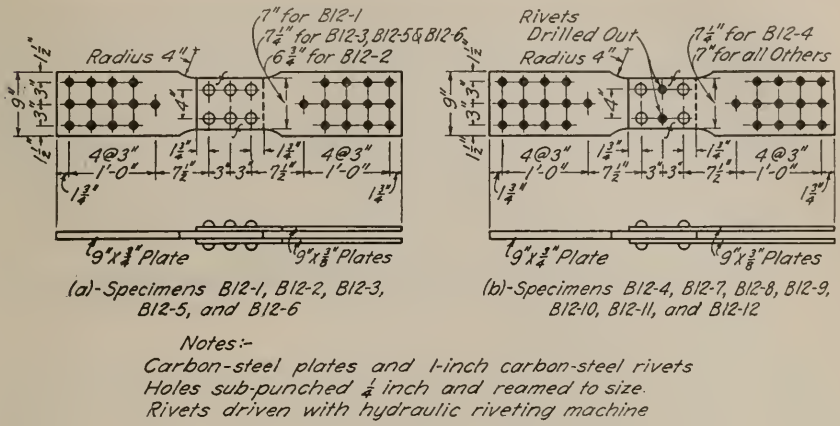


Fig. 2.—Typical Fatigue Specimens.

of the specimen and probably upon the properties of the material. This equation is represented on a double system of logarithmic coordinates by a straight line and. although it is empirical and not particularly accurate, is helpful in interpreting tests of a limited number of identical specimens.

3. Results of Fatigue Tests

The fatigue tests of riveted joints, described in detail in Bulletin 302, have been summarized as follows:

For joints designed to fail in the rivets and for a fatigue strength based upon failure at 2,000,000 cycles—

(a) The results of tests in which the shear on the rivets was repeated but not reversed were fairly consistent, and indicate that the fatigue strength of rivets under repeated stress is of the order of 30,000 lb. per sq. in. shear on the rivets.

(b) The results of tests in which the shear on the rivets was completely reversed were very inconsistent, and indicated that the fatigue strength of rivets under reversed stress may be as high as 30,000 or as low as 15,000 lb. per sq. in. shear on the rivets.

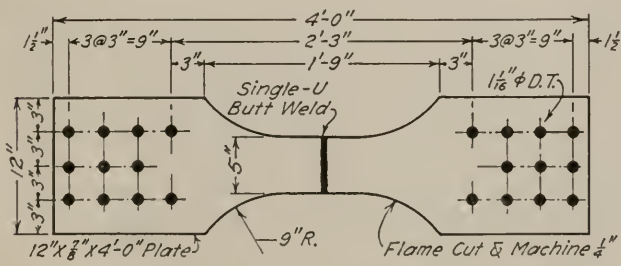


Fig. 3.—Details of Specimen for Tests of Butt-Welds in ⅞-in. Carbon Steel Plates.

(c) For the joints subjected to complete reversals of stress, the life of the rivets was much greater for joints with plates having milled ends in contact so as to take compression by direct bearing than it was for joints for which the ends of the plates were not in contact.

(d) The fatigue strength of high-strength bolts, appreciably smaller than the holes in the plates, was as great as that of well-driven rivets if the nuts were screwed up to give a high tension in the bolts.

(e) There was some evidence indicating that, for specimens subjected to a complete reversal of stress, the life of the rivets or bolts of the joint will be short if the first few cycles of stress cause an appreciable slip.

(f) Specimens of balanced design, T:S:B (tension:shear:bearing) ratio of 1.00 : 0.75 : 1.50, will fail in the plate if subjected to a cycle in which the stress is repeated but not reversed.

The fatigue strength of carbon-steel[5] plates in joints designed to fail in the plates (T:S:B = 1.00 : 0.60 : 1.26), when tested on cycles having various ratios of minimum to maximum stress had the values given in Table 1, the fatigue strength being based upon failure at 2,000,000 cycles in each instance.

TABLE I

Stress Variation	*Fatigue Strength lb. per sq. in. of* *Net Section*	*Gross Section*
Tension to an equal compression	19,700	13,500
Zero to tension	28,600	19,500
Tension to tension one-half as great	39,000	26,500

The fatigue strength of the plates in a riveted joint of balanced design subjected to a cycle in which the stress varied from 0 to a maximum tension was approximately 26,000 lb. per sq. in. of net section or 18,900 lb. per sq. in. of gross section. This value was practically the same whether the plates were of carbon steel with a static strength of 63,000 lb. per sq. in., of silicon steel with a static strength of 80,000 lb. per sq. in. or of nickel steel with a static strength of 99,000 lb. per sq. in.

The fatigue tests of welded joints, described in detail in Bulletin 327, have been summarized in the Tables 2, 3 and 4. In general, each value is the average of three or more tests.

4. The Character of Fatigue Failure

The phenomenon that results in the failure of a structural steel member after a large number of repetitions of a relatively low stress, usually referred to as a "fatigue" failure, has been made more difficult to understand because of its unfortunate name. Designating it as a fatigue failure implies that the whole volume of metal involved has been damaged. In fact, the popular conception is that fatigue failure is due to a slow recrystallization of the metal. Students of the phenomenon are generally agreed, however, that such is not the case. Microscopic examination shows that the metal adjacent to a fatigue crack has not suffered any change in grain structure. Static tests of fatigue specimens that have been subjected to a large number of cycles of high stress without failure[6] show no appreciable change in either strength or ductility.

[5] Yield point 34,400 lb. per sq. in.; ultimate strength 63,500 lb. per sq. in.
[6] Bulletin 327, p. 32, Table 17.

What is generally known as a fatigue failure might more properly be called a "progressive" failure. Any discontinuity, hole, inclusion, surface scratch, or abrupt change in section of a stressed member is a stress raiser. The effect of a stress raiser is to produce an intensity of stress in its immediate vicinity considerably in excess of the average stress across the section. For example, a round hole in a steel plate in tension will produce a stress at the edge of the hole two or three times the average stress on the transverse section through the hole, the exact relation of the maximum to the average

TABLE 2

FATIGUE STRENGTH OF BUTT WELDS IN ⅞-IN. CARBON STEEL PLATES

Description of Specimen	*Fatigue Strength in 1,000's of Lb. Per Sq. In.*					
	Tension to an Equal Compression		*0 to Tension*		*Tension to Tension Half as Great*	
	N = 100,000	*N =* 2,000,000	*N =* 100,000	*N =* 2,000,000	*N =* 100,000	*N =* 2,000,000
As welded	22.3	14.4	33.1	22.5	53.3	36.9
Reinforcement on, stress relieved	21.3	15.1	31.9	23.7	...	37.6
Reinforcement machined off, not stress relieved	28.9	...	48.8	28.4	...	43.7
Reinforcement machined off, stress relieved	24.5	16.6	49.4	27.8	...	42.6
Reinforcement ground off, not stress relieved	26.8	...	44.5	26.3	...	...
Plain plate, mill scale on	27.7	17.1	49.8	31.6	...	50.0
Plain plate, mill scale machined off and surface polished	...	...	59.6	...	...	...
Butt weld. Reinforcement and mill scale machined off and surface polished	...	...	53.9	...	...	...

stress depending upon the relation of the diameter of the hole to the width of the plate and upon the relation of the average stress to the elastic limit of the material. The ratio of the maximum to the average stress is known as the stress-raising factor.

The manner in which a stress raiser causes failure at an average stress considerably below the static ultimate of the material has been conceived to be as follows: Consider a riveted structural steel member made of a steel with an elastic limit of 33,000 lb. per sq. in. to be subjected to a large number of cycles in which the average stress across the section varies from 0 to 10,000 lb. per sq. in. Suppose that the rivet holes have a

TABLE 3

FATIGUE STRENGTH OF JOINTS IN LOW-ALLOY STEEL PLATES

Stress Cycle—Tension to an Equal Compression

Description of Specimen	*Fatigue Strength in 1,000's of Lb. Per Sq. In.*			
	Based on Net Section		*Based on Gross Section*	
	N = 100,000	*N =* 2,000,000	*N =* 100,000	*N =* 2,000,000
Butt Weld	...	...	25.7	15.4
Double-strap riveted butt joint	23.9	15.7	20.1	13.3

TABLE 4

FATIGUE STRENGTH OF PLATES WITH TRANSVERSE FILLET WELDS
PLATE CONTINUOUS

Stress Cycle—Tension to an Equal Compression

Kind of Steel	*Type of Specimen*	*Fatigue Strength, 1,000's of Lb. Per Sq. In.* $N = 100,000$	$N = 2,000,000$
Carbon	Continuous plate without weld	25.8	22.8
	Continuous plate with transverse fillet welds on one side	25.4	18.9
	Continuous plate with transverse fillet welds on both sides	22.9	13.1
Low-Alloy	Continuous plate without weld	35.3	26.4
	Continuous plate with transverse fillet welds on one side	31.7	23.9
	Continuous plate with transverse fillet welds on both sides	22.2	10.1

stress-raising factor of three. Under these conditions, when the average stress increases from 0 to 10,000 lb. per sq. in., the maximum stress will increase to 30,000 lb. per sq. in. Since no portion of the material has been subjected to plastic flow, its physical properties will not have been changed and an infinite number of cycles will not cause failure. If, however, the average stress during a cycle varies from 0 to 20,000 lb. per sq. in., the stress at the edge of the stress raiser will exceed the elastic limit of the material and plastic flow will occur over a small area. The maximum stress, however, will not equal $3 \times 20,000$ lb. per sq. in. but something less than that, because the stress-raising phenomenon, while affecting strain directly, affects the stress indirectly and only because it affects the strain. That is, a discontinuity that has a stress-raising factor of three when the maximum stress is below the elastic limit of the material will have a smaller stress-raising factor if the maximum stress exceeds the elastic limit. But the localized plastic flow that accompanies the first application of the stress increases the elastic limit adjacent to the stress raiser so that the second application of the load will result in a somewhat higher maximum than the first cycle. This increase in stress adjacent to a stress raiser continues with succeeding cycles until a minute fracture is produced. The fracture is a stress raiser and the maximum stress is at the advance edge. Under these conditions, the succeeding cycles of stress cause the fracture to grow until it covers so much of the section that the remaining portion fails abruptly in much the same manner as the static failure of a deeply notched specimen. The number of cycles from the time the micro-fracture is first formed until final failure occurs depends upon the properties of the material and upon the character of the stress raiser. This progressive period of the fracture may require only a few thousand cycles or it may require several hundred-thousand cycles.

It is apparent from the discussion in the preceding paragraphs that, in considering the importance of fatigue failure upon the design of steel bridge members, three facts should be kept clearly in mind.

1. Failure under repeated loads is a "progressive" failure and not really a fatigue failure.
2. Material adjacent to the micro-fractures is not injured but retains its original properties.
3. Micro-fractures developed by repetitions of stress, grow slowly and, with proper inspection, should be detected before they are large enough to cause failure.

5. Influence of the Fatigue Strength of Structural Members Upon Their Design

Checking the design of a structural member against fatigue failure differs from checking against failure under a single application of a load in two respects.

1. In checking a design against failure under a single application of the load, the maximum possible stress is used. In checking against fatigue, only stresses that are likely to occur a large number of times should be considered.
2. Failure under a single application of a load occurs during a short interval of time and the load that will cause failure having been applied, the member will fail before the load can be removed. In contrast with this, fatigue failure is progressive and will extend over a long period of time, thus affording an opportunity for the crack to be discovered before it becomes dangerous.

Both of these factors affect the influence of fatigue upon design. The first affects the number of cycles for failure upon which the fatigue strength should be based; the second affects the ratio of the fatigue strength of the member to the stress to which the member is to be subjected a large number of times, really the factor of safety.

Single-application stresses for which a bridge is designed are based on the assumptions:

1. The full design live load is on the bridge and it is located so as to produce the maximum possible stress in the member considered.
2. The load is moving at the speed that produces the maximum impact.

The load seldom complies with assumption 1 except as the bridge is used for traffic much heavier than that for which it was designed and generally does not comply with assumption 2. The instances in which the loading conditions comply with both assumptions simultaneously are relatively few except for special lines used almost exclusively for hauling heavy freight. Even for bridges on a line of this class the number of trains or fleets of trucks that comply with both of these assumptions is quite small. And it should be remembered that a relatively small reduction in the maximum stress in a stress cycle greatly reduces the fatigue effect of the cycle.

Some members of a bridge, such as the chords of a simple truss, are subjected to a single complete stress cycle during the passage of a train or fleet of trucks. Other members, such as hip verticals, floorbeams and stringers, and connections for the same, are subjected to a complete cycle of stress by the passage of an axle or group of axles. Obviously members of the second class will be subjected to a larger number of cycles during their life than members of the first class, and they should be considered separately when checking against fatigue failure.

The chord members of a simple-truss single-track railway or two-lane highway bridge are subjected to only one complete cycle of stress due to the passage of a train or fleet of trucks. Any bridge that carries a train or a fleet of trucks every 15 min., night and day, would be considered a "hot" bridge. This is equivalent to 35,000 cycles per year, 350,000 cycles in 10 years or 1,750,000 cycles in 50 years.

In view of the above discussion it would seem that, although the truss chords of an unusually busy bridge might be subjected to 1,500,000 to 2,000,000 cycles during their life, the probable number of cycles in which the stress approximates the single-application stress used in design would be very much smaller. It is believed that, for the purpose of checking against fatigue failure, the fatigue strength of chord members of simple trusses and of other members subjected to only one complete stress cycle during the passage of a train or a fleet of trucks should be based upon failure at 100,000 cycles.

The number of cycles of stress during its life is even more uncertain for a hip vertical of a truss (or other member subjected to a complete cycle due to the passage of a single axle or small group of axles) than it is for the chord. Only cycles for which the maximum stress is nearly as great as the single-application stress used in the design will contribute materially to fatigue failure. The maximum hip-vertical stress in a railway bridge is usually due to the locomotive drivers and really occurs only once for the passage of each locomotive. But the number of locomotives which equal in weight the locomotive used in design will be much greater than the number of trains which equal in weight the trains used in design. Also in any train, however small its average weight, there may be heavy freight cars which will produce a stress in hip verticals, and other similar members, nearly as great as that produced by locomotive axles; and these heavy car axles increase the liability of fatigue failure. Moreover, the total number of passages will be many times greater for axles or small groups of axles than for trains or fleets of trucks. It would seem, therefore, in checking against fatigue failure of the hip verticals and other members subjected to a cycle of stress during the passage of a single axle or small group of axles, that the fatigue strength should be based upon failure at a number of cycles of the order of 2,000,000.

In designing multiple-track railway bridges and multiple-lane highway bridges, the possibility of two or more tracks and four or more lanes being loaded simultaneously must be considered. Although the *possibility* of these load combinations occurring occasionally is recognized, the *probability* of their occurring *frequently* is so remote that they would not likely contribute to fatigue failure except in unusual locations. It would appear adequate, therefore, in designing multiple-track and multiple-lane bridges, to design for single-application stresses due to loads on two or more tracks and four or more lanes, as at present, and then check against fatigue failure due to loads on only one track or two lanes, for railway and highway bridges, respectively.

As stated previously, fatigue failure is progressive and extends over such a long period of time that a crack should be discovered before it becomes dangerous. For this reason it would seem permissible for the ratio of the fatigue strength to the fatigue stress to be smaller than the ratio of the static strength to the single-application stress usually used in design. It is suggested that, in checking against fatigue failure, the allowable stress in fatigue be taken as two-thirds of the fatigue strength, the fatigue strength and the fatigue stress being for the same ratio of minimum to maximum stress in the stress cycle and for the same number of cycles for failure.

Although 100,000 and 2,000,000 cycles for failure have been specified as the bases for the fatigue strength of certain stipulated members after considering the services to which the members are subjected, the selection of these numbers of cycles should be considered tentative and subject to critical review. Likewise, the selection of two-thirds as the ratio of the design fatigue stress to the fatigue strength is based largely upon judgment and is subject to review by the profession.

6. Unit Stresses Recommended for Use in Checking Against Fatigue Failure

Carbon Steel Plates of Riveted Tension Members

It is apparent from the discussion in the previous sections that the unit stress to be used in checking a design against fatigue failure is likely to have different values for various structures and for the various members of the same structure, depending upon the character of the stress cycle and the frequency of cycles having a maximum stress nearly equal to the single-application stress used in the design.

The AREA Specifications for Steel Railway Bridges require that, for a tension member subjected to reversed or pulsating axial loads, the area of the net section of the

member shall be not less than $\frac{\text{max.} - \frac{1}{2}\text{ min.}}{18{,}000}$, but not less than $\frac{\text{max.}}{18{,}000}$. In this expression a tension is plus (+) and a compression is minus (—).

The fatigue strength of a properly designed riveted tension member is the fatigue strength of the end connection. The fatigue strength of the end connection is the fatigue strength of the plates, angles and channels or the fatigue strength of the rivets, whichever is the lesser.

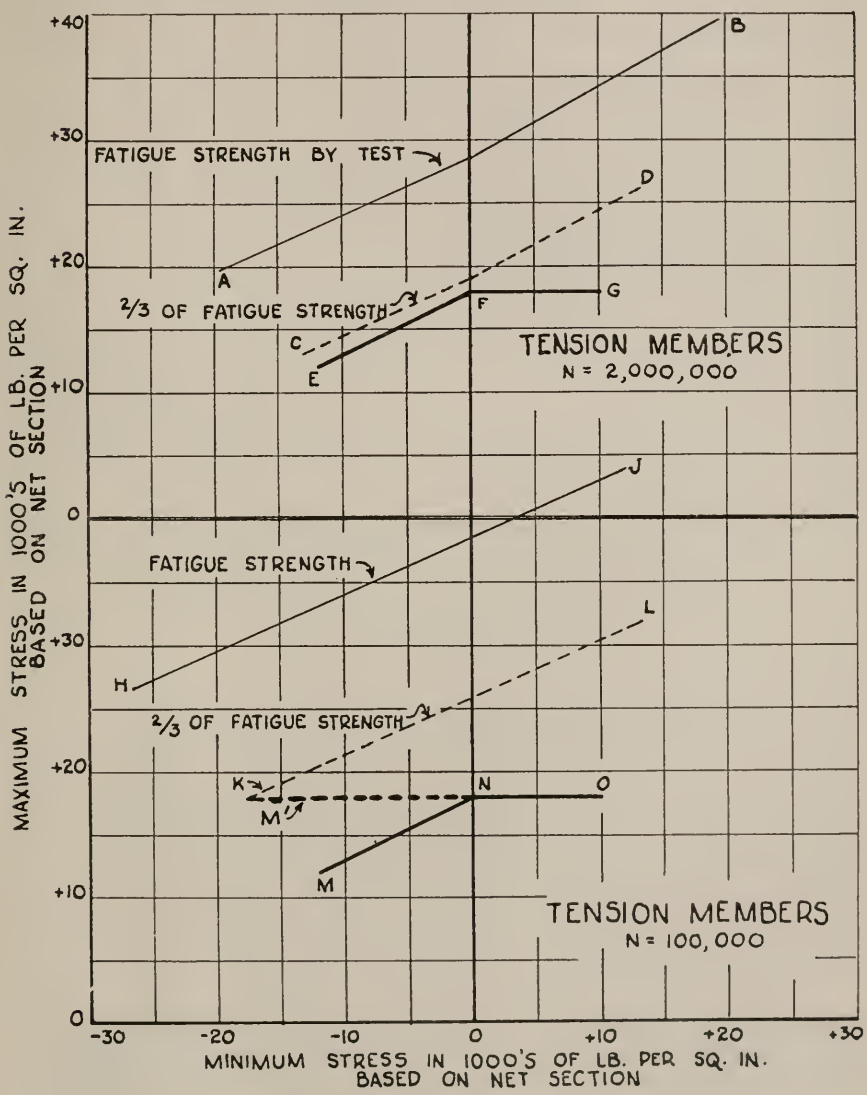


Fig. 4.—Design Fatigue Stresses.
Carbon Steel Plates with Riveted Connections.

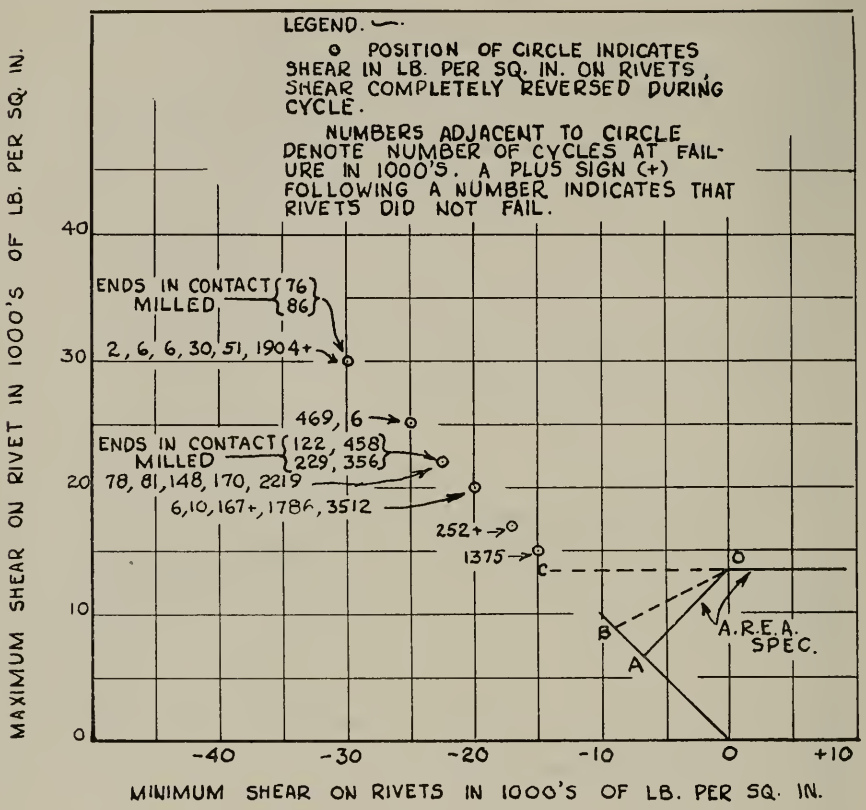


Fig. 5.—Design Fatigue Stresses.
Carbon Steel Rivets. N = 100,000.

The fatigue strength of carbon steel plates of riveted joints, as given in Bulletin 302, p. 76, and based on failure at 2,000,000 cycles, is represented by the line *AB* of Fig. 4. The dotted line *CD* represents two-thirds of the fatigue strength, a value that was suggested in Section 5 as a proper design stress. The line *EFG* represents the unit stress for members subjected to reversed and pulsating stresses allowed by the AREA specifications. These unit stresses are based on the net section. Inasmuch as the stresses allowed by the AREA specifications are slightly lower than two-thirds of the fatigue strength as determined by tests, it would seem that the present specifications are satisfactory for carbon steel riveted members which are to be subjected during their life to approximately 2,000,000 applications of a reversed or pulsating stress nearly equal to the single-application stress for which the member is designed.

The diagrams of the lower portion of Fig. 4 are for a carbon steel member subjected to 100,000 cycles. It is of interest to note that two-thirds of the fatigue strength for failure at 100,000 repetitions of a cycle in which the stress is completely reversed, equals the usual working stress in tension, 18,000 lb. per sq. in. of net section. This suggests that the present requirements, insofar as they apply to chords of trusses and other members subjected to only one complete cycle of stress for each passage of a train or

fleet of trucks, might be needlessly conservative for *the plates* of riveted tension members. Unfortunately information relative to the fatigue strength of rolled or built-up tension members of channel or I-sections is not available. Any change in the specifications should therefore be delayed until more complete information is available.

7. Unit Stresses Recommended for Use in Checking Against Fatigue Failure Carbon Steel Rivets of Riveted Tension Members

There is very little information available relative to the fatigue strength of the rivets of a riveted joint. Some tests are reported in Bulletin 302, and the results of these tests have been summarized in Section 3.

The AREA Specifications for Steel Railway Bridges require, for a member subjected to a reversal of stress, that the rivets be designed for the numerical sum of the maximum tension and maximum compression to which the member is to be subjected. This requirement, shown graphically by the line *OA* of Fig. 5, is equivalent to a unit shear of 6,750 lb. per sq. in. for a complete reversal. The results of individual tests are shown in the figure by the small circles. The circle just above *C* shows that, for a specimen in which the shear on the rivets varied from 15,000 lb. per sq. in. in one direction to an equal shear in the opposite, a rivet failed at 1,375,000 cycles. Several specimens were tested at each of a number of cycles as shown, nine at a cycle in which the shear on the rivets varied from 22,000 lb. per sq. in. in one direction to an equal shear in the opposite direction. Of these, four had milled ends in contact under a 5-ton pressure when riveted, as noted in the figure.

The specimen that showed the lowest fatigue strength is the one that failed at 10,000 repetitions of a cycle in which the shear on the rivet varied from 20,000 lb. per sq. in. shear in one direction to an equal shear in the opposite direction. An identical specimen withstood 1,375,000 repetitions of a cycle in which the shear on the rivet varied from 15,000 lb. per sq. in. in one direction to an equal shear in the opposite direction. (The specimens that failed at 6,000 cycles, shear + to — 20,000 and + to — 25,000 lb. per sq. in., had only one transverse row of rivets and the rivets were subjected to a flexure that would not occur in connections such as would be used in a structure). Even after giving full weight to these scattered low values, it would seem that the present requirements for designing rivets subjected to reversed stresses are needlessly conservative for splices in the chords of trusses and other members subjected to a relatively small number of stress cycles during their life. It is recommended that the area of the rivet section subjected to shear be not less than $\frac{\text{maximum stress} - \frac{1}{2}\text{ minimum stress}}{13{,}500}$ for carbon steel rivets connecting load bearing members in contact (no fills) which will be subjected to 100,000 cycles during their life. This requirement is represented by the line *OB,* Fig. 5. If all rivets had even one-half the fatigue strength of some that were tested, no increase in the number of rivets because of fatigue would be necessary for members subjected to 100,000 complete reversals. The present specifications should be retained for members subjected to 2,000,000 cycles until further information is available.

Tests were made on some connections in which high strength bolts were used instead of rivets. These tests have been summarized as follows:

> The results of the individual tests are given in Table 18 (Bulletin 302). According to the data in this table the values of the fatigue strengths of the bolts, in lb. per sq. in. shear on the bolts, are 55,410, 39,300 and 35,200 for bolts for which the values of the initial tension were 30,000, 19,400 and 9,925 lb. per sq. in., respectively.

This was for $1\frac{1}{32}$-in. bolts in $1\frac{1}{16}$-in. holes, failure at 2,000,000 repetitions of a cycle in which the shear was completely reversed.

Low fatigue strength of rivets seems to be closely associated with relatively large initial slip at early loadings. Slip in a joint subjected to reversed loads is objectionable irrespective to its effect upon the fatigue strength of the joint. An increase in the number of rivets required for a large joint due to the use of a needlessly low design fatigue strength, adds greatly to the size and cost of the joint and is highly undesirable. It, therefore, would seem advisable to determine:

1. How to drive rivets to have a small slip up to 1.5 times the design stress.
2. Make a more exhaustive study of the fatigue strength of properly driven rivets.
3. Consider the feasibility of using high strength bolts (not of a driving fit) as a substitute for rivets for joints subjected to a reversal of stress.

8. Unit Stresses to be Used in Checking Against Fatigue Failure Silicon Steel Plates of Riveted Tension Members

The fatigue strength of silicon-steel plates of riveted joints,[7] based on failure at 2,000,000 cycles, is given by the line *AB* in the upper portion of Fig. 6. Only one point on this line, *B'*, was determined experimentally, the one giving the fatigue strength based upon failure at 2,000,000 repetitions of a cycle in which the stress varied from zero to a maximum tension. The slope of the line *AB* was assumed to be the same as for the corresponding line for carbon steel, line *AB* of Fig. 4. The need for further tests to determine more definitely the slope and position of this line is fully recognized, and the following discussion is based upon the tentative acceptance of the fatigue values represented by the line *AB*.

The line *CD* represents two-thirds of the fatigue strength. If silicon steel members subjected to 2,000,000 cycles of stress were designed for a basic stress of 24,000 lb. per sq. in., the allowable unit stress for various ratios of minimum to maximum stress would be as represented by the line *EFG*. But line *EFG* lies above the line *CD* and represents values entirely too high to be used in design. Because the fatigue strength of silicon steel plates is very nearly the same as the fatigue strength of carbon steel plates, the following restriction relative to the design of alloy steel members subjected to fatigue has been incorporated in the specifications.[8]

> On account of the possibility of fatigue failure, the allowable unit stresses in Article 1601 (for alloy steels) shall not apply to members that will be subjected to a large number of stress cycles during the life of the bridge and having either reversal of stress or low dead load stress. For such members the allowable unit stress shall be reduced, and in floor systems shall not exceed those specified in Article 301 (which are for carbon steel).

According to this restriction, the basic stress for silicon steel plates in fatigue would be 18,000 lb. per sq. in. The line *E'F'G'* represents the allowable unit stress in fatigue for various ratios of minimum to maximum stress for a basic stress of 18,000 lb. per sq. in. Although the line *E'F'G'* lies slightly above the line *CD*, it is believed that a basic stress of 18,000 lb. per sq. in. is acceptable for *silicon steel plates* that are to withstand 2,000,000 cycles.

---

[7] Bulletin 302, p. 103.
[8] AREA Specifications for Steel Railway Bridges, Part 3—Alloy Steels, Foreword, paragraph 9.

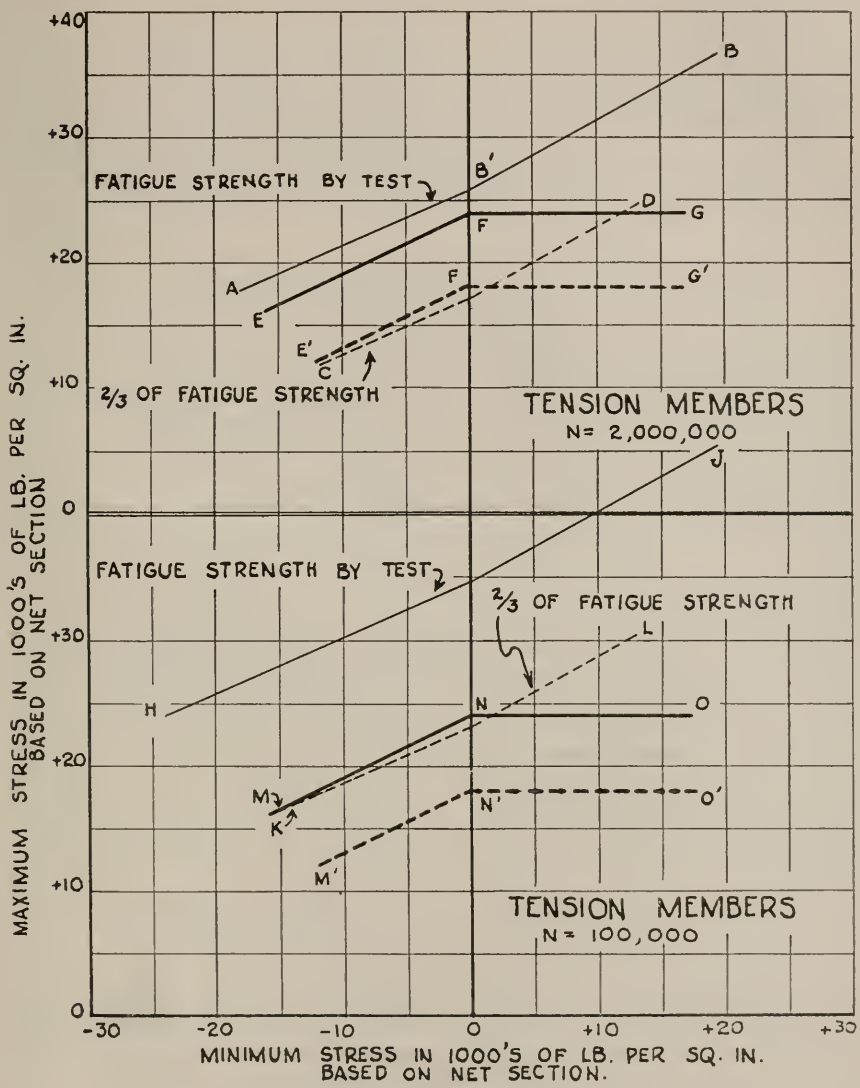


Fig. 6.—Design Fatigue Stresses.
Silicon Steel Plates with Riveted Connections.

No data are available giving the fatigue strength of angles, channels or I-beams with riveted connections.

The line *HJ* of Fig. 6 represents the probable fatigue strength of silicon steel plates of riveted joints based upon failure at 100,000 cycles. No tests have been made giving the fatigue strength for failure at 100,000 cycles. Instead the line *HJ* has been drawn to have the same relation to *AB* that the line *HJ* of Fig. 4 bears to *AB* of Fig. 5. There is some evidence indicating that if carbon steel and silicon steel have the same fatigue

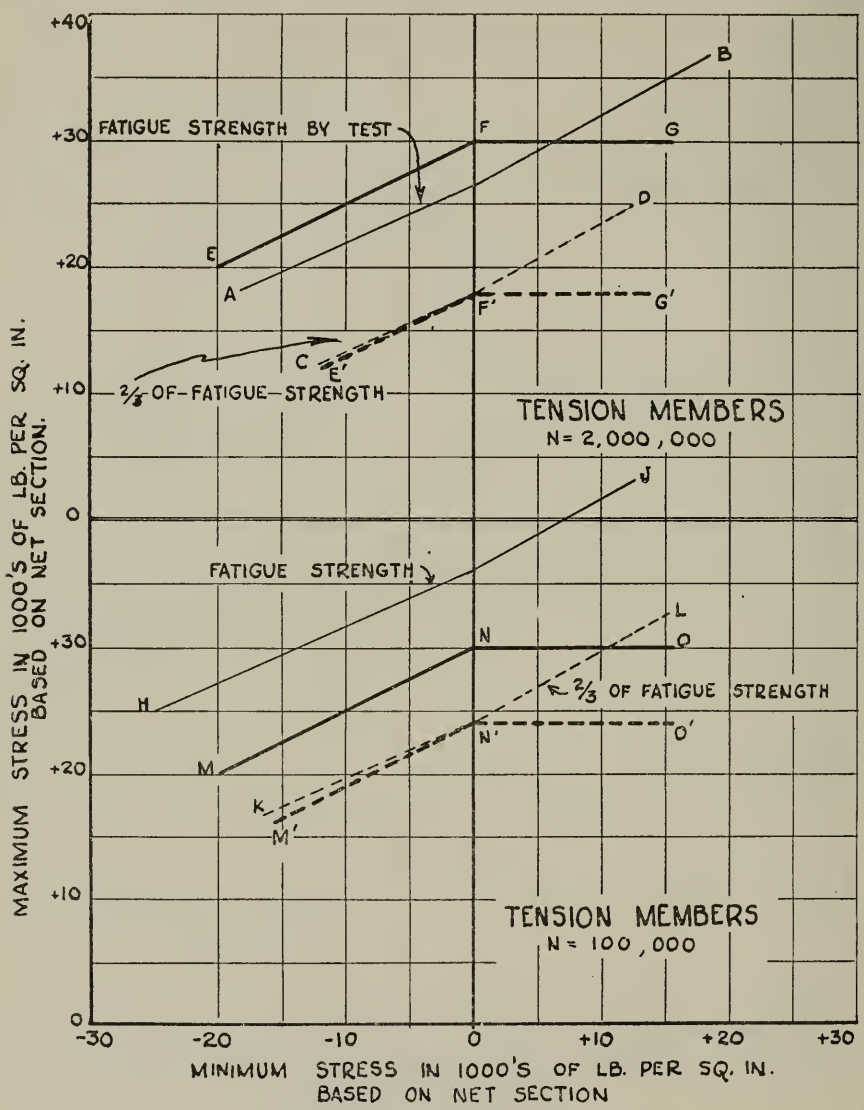


Fig. 7.—Design Fatigue Stresses.
Nickel Steel Plates with Riveted Connections.

strength for failure at 2,000,000 cycles, the fatigue strength for failure at 100,000 cycles will be somewhat higher for silicon than for carbon steel. Therefore, while the fatigue strength represented by the line *HJ* of Fig. 6 must be considered as only an approximation, the true values probably lie somewhat above this line. The line *KL* represents two-thirds of the fatigue strength given by *HJ*. If silicon steel members subjected to 100,000 cycles of stress were designed for a basic stress of 24,000 lb. per sq. in., the allowable unit stress for various ratios of minimum to maximum stress would be as represented by

the line *MNO*. Line *KL* lies only slightly below the line *MN*, and it would seem that if *HJ* really represents the fatigue strength of silicon steel plates connected with riveted joints, then members subjected to fatigue would be safe if a basic stress of 24,000 lb. per sq. in. were used in designing riveted tension plates to withstand 100,000 cycles of stress. The broken line, *M'N'O'*, represents the design stress for various ratios of minimum to maximum stress based upon a unit stress of 18,000 lb. per sq. in.

It is highly desirable to make tests to determine the fatigue strength of silicon steel angles, channels and I-beams with riveted connections as well as to make additional tests of silicon steel plates.

9. Unit Stresses to be Used in Checking Against Fatigue Failure Nickel Steel Plates of Riveted Tension Members

The fatigue strength of nickel steel plates of riveted joints,[9] based on failure at 2,000,000 cycles, is given by the line *AB* in the upper portion of Fig. 7. As in the case of silicon steel plates, only one point on this line was determined experimentally, the one giving the fatigue strength based upon failure at 2,000,000 repetitions of a cycle in which the stress varied from zero to a maximum tension. The slope of the line was assumed to be the same as for the corresponding line for carbon steel, line *AB* of Fig. 4. The need for further tests to determine more definitely the slope and position of this line is fully recognized, and the following discussion is based upon the tentative acceptance of the fatigue values represented by the line *AB*.

The line *CD* represents two-thirds of the fatigue strength. If nickel steel members subjected to 2,000,000 cycles of stress were designed for a basic stress of 30,000 lb. per sq. in., the allowable unit stress for various ratios of minimum to maximum stress would be as represented by the line *EFG*. But line *EFG* not only lies above *CD* but also above *AB* for most of its length. The fatigue strength of the nickel steel plates is very nearly the same as the fatigue strength of carbon steel plates and the limitations as to the design of alloy steels subject to fatigue, quoted in the previous section, would seem to be applicable to nickel steel. This provides for a basic stress of 18,000 lb. per sq. in. The line *E'F'G'* represents the allowable unit stress in fatigue for various ratios of minimum to maximum stress for a basic stress of 18,000 lb. per sq. in. It would seem acceptable for nickel steel plates but is not necessarily acceptable for nickel steel angles, channels and I-beams.

The line *HJ* of Fig. 7 represents the probable fatigue strength of nickel steel plates of riveted joints based upon failure at 100,000 cycles. As in the case of silicon steel, this line is based upon the line *AB* and is even more liable to error than the latter. The line *KL* represents two-thirds of the fatigue strength. If nickel steel members subjected to 100,000 cycles of stress were designed for a basic stress of 30,000 lb. per sq. in., the allowable unit stress for various ratios of minimum to maximum stress would be as represented by the line *MNO*. This line is considerably above the line *KL*, which represents the allowable design stress for a member subjected to 100,000 cycles, and it would seem that a basic stress of 30,000 lb. per sq. in. is too high to be used in the design. The line *M'N'O'* represents the allowable unit fatigue stress at various ratios of minimum to maximum stress cycles for a basic stress of 24,000 lb. per sq. in. Since the line *M'N'O'* coincides with or falls below the line *KL*, it would seem permissible to use a basic design stress of 24,000 lb. per sq. in. in designing nickel steel plates that will be subjected to 100,000 cycles of near maximum stress during their life. This puts nickel steel on a par with silicon steel for plates designed to withstand a limited number of cycles of stress.

[9] Bulletin 302, p. 103.

No data are available giving the fatigue strength of nickel steel angles, channels or I-beams.

10. Unit Stresses to be Used in Checking Against Fatigue Failure Butt Welds in Carbon Steel Plates

The fatigue strength of butt welds in carbon steel plates for failure at 2,000,000 cycles is given by the line *AB* of Fig. 8. The line *CD* represents two-thirds of the fatigue

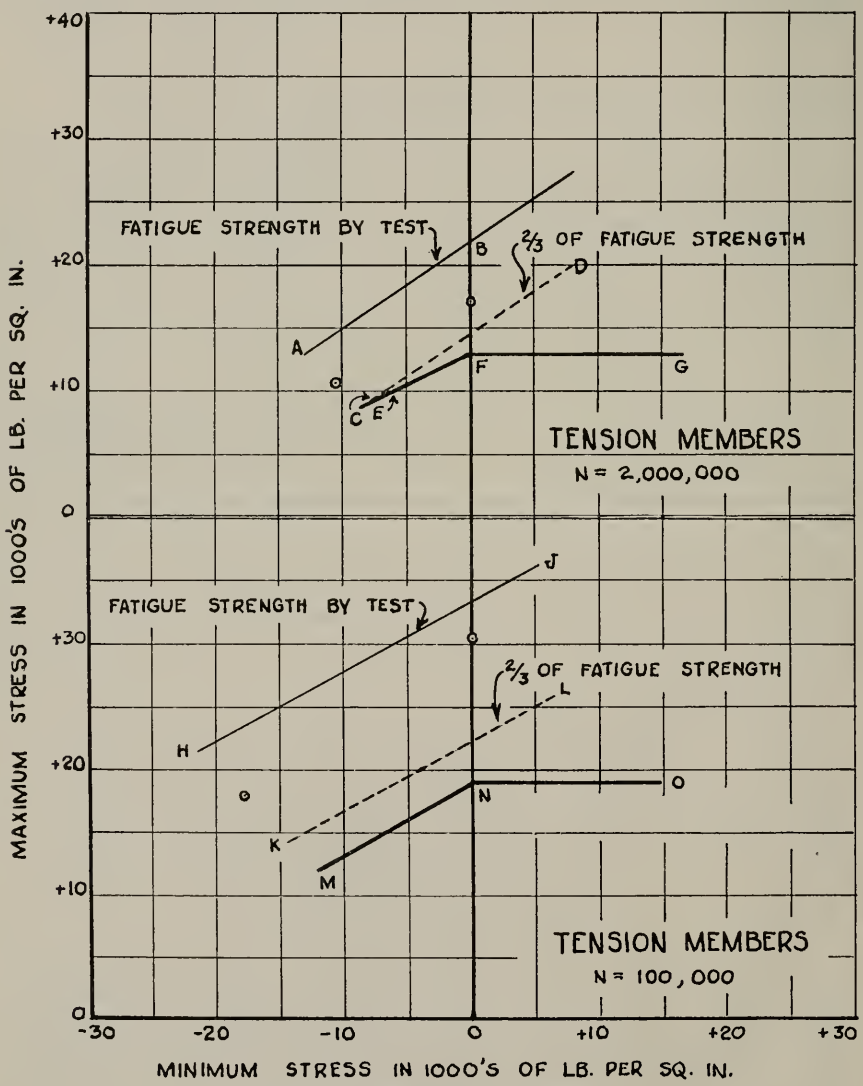


Fig. 8.—Design Fatigue Stresses.
Butt-Welds in Carbon Steel Plates.

strength and *EFG* represents a design specification with a basic stress of 13,000 lb. per sq. in. It should be noted that the unit stress is based upon the gross section for butt welds and upon the net section for riveted joints.

The fatigue strength is generally considered to be more erratic for welded than for riveted joints. The points *A* and *B* each represents the average of 23 or more tests and the small circle represents the minimum value for an individual test of the corresponding group.

The line *EFG* falls below *CD* and well below the small circles, and it would seem to represent a satisfactory design stress for butt welds in carbon steel plates that are expected to be subjected to 2,000,000 applications of the single-application stress used in the design.

The fatigue strength of butt welds in carbon steel plates for failure at 100,000 cycles is given by line *HJ*. The line *KL* represents two-thirds of the fatigue strength and *MNO* represents a design specification with a basic stress of 18,000 lb. per sq. in. The points *H* and *J* each represents the average of 23 tests and the small circle represents the minimum value for an individual test of the corresponding group. It would seem, therefore, that the proposed specifications for the design of butt welds in plates subjected to a single cycle of stress due to the passage of each train or fleet of trucks are satisfactory. This is a little less conservative than the present AWS specifications for welded bridges.

The statements in this section apply only to members consisting of plates with butt-weld connections. They do not necessarily apply to other types of welds or to rolled sections other than plates.

Summary

1. Fatigue failure is really a progressive failure. High localized stresses that cause little or no damage by a single application, by a larger number of repetitions, develop an incipient crack that grows with additional applications until failure finally occurs without damage to adjacent material.

2. Stress raisers produce the high localized stresses that lead to fatigue failure. The stress raisers most commonly experienced in bridge construction are rivet holes, abrupt changes in section, concave and re-entrant cuts, surface imperfections due to either rolling or fabrication and, for welded joints, undercutting, lack of penetration, porosity, slag inclusions, thermal cracks or excessive thermal stresses, reinforcement on butt welds, the abrupt change in section inherent in transverse fillet welds, and the accumulation of stress at the ends of longitudinal fillet welds.

3. The fatigue strength of a structural member subjected to axial loads is limited to the fatigue strength of the connections. For a riveted joint, the fatigue failure may be in the plates or rolled sections and will be through the rivet holes; or it may be a failure of the rivets. For a properly made butt weld in carbon steel, reinforcement on, failure will be at the edge of the reinforcement; for a poor weld it may be through the weld metal. For a joint with longitudinal fillet welds, failure will be in the main member and at the end of the welds; for a joint with transverse fillet welds, failure will be in the main member at the edge of the fillet. The fatigue strength of a continuous member (one without joints) is greatly reduced by transverse fillet welds, and possibly to a less extent, by longitudinal fillets. Plug and slot welds reduce the fatigue strength of connected members much the same as rivet holes.

4. The fatigue strength depends upon the ratio of the minimum to the maximum stress in the stress cycle and upon the number of cycles of stress the member is expected to withstand during its life. Few bridge members are subjected to a complete reversal

of stress, a somewhat larger number are subjected to a large stress of one sign and a small stress of the opposite sign. Most bridge members are subjected to a pulsating stress, maximum and minimum of the same sign, and the ratio of the minimum to the maximum depends upon the relation of the dead to the live load.

The number of cycles to which a member will be subjected during the life of a structure varies for various structures and for various members of the same structure. The single-application stress used in design is the maximum possible and not the probable stress. A great number of applications of a stress considerably below the maximum contribute practically nothing to fatigue failure. For these reasons the number of cycles of stress that contribute to fatigue failure is a very small portion of the total number of cycles. As a basis for determining the fatigue strength to be used in design, bridge members have been arbitrarily divided into two classes, those designed to withstand 100,000 cycles and those designed to withstand 2,000,000 cycles, the maximum stress in the cycle being the same as the single-application stress used in the design. It is considered that 100,000 cycles of maximum stress is representative of the chords of trusses and other members subjected to only one cycle with each passage of a train or fleet of trucks, and that 2,000,000 cycles of maximum stress is representative of hip verticals and other members subjected to a complete cycle of stress with the passage of one axle or small group of axles. This classification is tentative and subject to critical review. Special members subjected to either a smaller or a larger number of cycles should receive special consideration.

5. It has been suggested that the stress to be used in checking the design of a bridge member against fatigue failure, be taken as two-thirds of the average fatigue strength as determined by tests, the ratio of the minimum to the maximum stress and the number of cycles for failure in the tests being applicable to the member being considered.

6. It is recommended that the allowable unit stress to be used in checking a riveted tension member against fatigue failure be as given by the equation—

$$A = \frac{\text{maximum} - \tfrac{1}{2}\,\text{minimum}}{p} \text{ but not less than } \frac{\text{maximum}}{p},$$

in which a compression is a negative tension, A is the net section of the member and p is the basic stress given in the specification. This is equivalent to Section 215 of the AREA Specifications for Steel Railway Bridges if p is taken equal to 18,000 lb. per sq. in. for carbon steel. In checking against failure by fatigue the value of p depends upon the kind of steel and upon the number of repetitions of stress for which the member is to be designed.

The values of p recommended for plates of the various steels and for a life of 100,000 and for a life of 2,000,000 cycles are as follows:

Kind of Steel	*Values of p in Lb. per Sq. In. of Net Section for a Life of*	
	100,000 Cycles	*2,000,000 Cycles*
Carbon	18,000	18,000
Silicon	24,000	18,000
Nickel	24,000	18,000

It is recommended that the same equation be used in checking carbon steel rivets against failure by fatigue with $p = 13{,}500$ lb. per sq. in. shear on the rivet for members to be subjected to 100,000 cycles. This is less conservative than Section 215 of the specifications.

Information is not available for checking angles, channels and I beams against fatigue.

7. It is recommended that the allowable unit stress used in checking a carbon steel plate of a tension member with butt-weld connections be as given by the equation in Paragraph 6 with p equal to 13,000 lb. per sq. in. for members designed to have a life of 2,000,000 cycles and equal to 18,000 lb. per sq. in. for members designed to have a life of 100,000 cycles. It is to be noted that for the plates of riveted connections, p is for the net section whereas for welded connections, p is for the gross section.

8. The recommendations relative to checking designs against fatigue failure are based upon good fabrication. Faulty details that may incorporate bad stress raisers will result in a fatigue strength much below that shown by the laboratory test. Particular care should be exercised in detailing members and connections subjected to reversed or pulsating loads to avoid stress raisers.

9. The recommendations relative to design practice given in the preceding paragraphs cover only a part of the field; experimental data are not available for the remainder and many of the recommendations given are based on wholly inadequate data. A large amount of experimental work remains to be done, both on welded and riveted connections.

MEMOIRS

MEMOIR

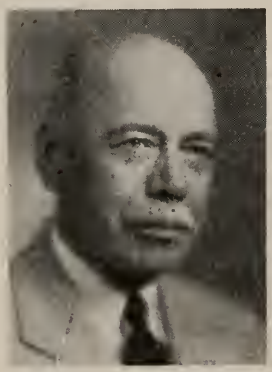
Robert H. Ford

Died, May 27, 1941

Robert H. Ford was born at St. Albans, Vt., on September 8, 1869. He died in Beverly Hills (Chicago) on May 27, 1941.

Mr. Ford was educated in the public schools of St. Albans, Vt., and then attended Norwich University, Northfield, Vt., graduating from that institution with the degree of civil engineer in 1892. While in college, he displayed that unusual energy and interest in varied activities that characterized his later professional life, for, in addition to his collegiate studies, he was a second lieutenant and adjutant in the student cadet corps, assistant editor and business manager of the "Reveille", and a member of the college baseball team, of which latter group he also served as its business manager in 1890–91. He was a member of the Theta Chi college fraternity.

Throughout his later years, Mr. Ford maintained a keen interest in his University and gave freely of his time and energy to the furtherance of its interests throughout his life. He served as vice-president of the General Alumni Association of the University in 1901–02 and as president in 1904–07. He was president of the St. Louis, Mo.,



Robert H. Ford

local alumni group in 1909–10. He also served as a member of the Board of Trustees of Norwich University for a number of years. His University fittingly awarded him the degree of Master of Arts in 1911 and the further degree of Doctor of Engineering in 1939.

Following graduation, Mr. Ford turned to the railways for his life's work, entering the employ of the Central Vermont as a member of its engineering corps. During the next 13 years he rose to positions of responsibility on this road, including those of roadmaster and construction engineer, in which latter capacity he was in charge of the location and construction of the Bethel (Vermont) Granite Railway.

In 1906, Mr. Ford saw greater opportunities on the larger railways of the Middle West and entered the service of the Missouri Pacific as an assistant engineer. Later in that year he was promoted to maintenance of way inspector and in 1907 he was again promoted to principal assistant engineer of that road. In 1909 he was further advanced to assistant to the chief engineer maintenance of way of the Missouri Pacific.

In 1911, Mr. Ford left railway service to become chief engineer of the Hodges–Downey Construction Company, general contractors at Birmingham, Ala. Two years later he entered the employ of the Chicago, Rock Island & Pacific as a special engineer. In the following year he was appointed engineer of track elevation and placed in charge of that road's large grade separation program that was then in progress in Chicago. In this capacity he developed an organization to handle this outstanding project with railroad forces under his immediate direction, in contrast with the prevailing practice of contracting such work, and in 1919, largely in recognition of the efficiency with which he conducted this work, he was promoted to principal assistant engineer; in 1924 he was further advanced to assistant chief engineer of the Rock Island. Mr. Ford was appointed chief engineer of the Rock Island System on April 1, 1937 and held this position until his retirement on September 30, 1939.

Mr. Ford was admitted to membership in the American Railway Engineering Association in 1908, beginning a long and unusually active participation in this Association's activities. He became a member of Committee 18—Electricity in 1916, and served on this committee until 1923. He was a member of Committee 22—Economics of Railway Labor from 1918 to 1924, and was chairman of Committee 24—Cooperative Relations with Universities from its creation in 1924 until it was discontinued in 1933. When the committee was reorganized and reinstated in 1939, Mr. Ford again became a member and took an active interest in its work until his death. He served as a member of Committee 25—Waterways and Harbors from 1932 to 1934, and when Committee 25 was supplemented by the Special Committee on Engineering Research, Inland Waterways and Intercoastal Canals in 1933, Mr. Ford was appointed chairman of this latter committee, being deeply interested in its work and rendering especially valuable service. He was also a member of Committee 4—Rail from 1937 to 1939.

Mr. Ford was elected a director of the Association in 1926 and served in that capacity for three years. He was elected vice-president in 1933 and served as such for two years. He was then elected president in 1935. In all these capacities, he showed an energy of purpose and an originality of view that were highly stimulating to the Association, with the result that a not inconsiderable number of innovations first proposed by him have since become current practice in the organization.

Mr. Ford recognized his responsibility to his community and took an active part in local activities on numerous occasions. When resident in St. Albans, Vt., he served as a member of the local Board of Education and also as a member of the State Normal School Board of Vermont. Likewise in Chicago, he was a member of the Beverly Hills Improvement Association and contributed in no small way to the solution of such engineering problems as came before that group. He became a Mason while in Vermont and maintained that affiliation until his death. He was a member of Holy Nativity Episcopal Church in Beverly Hills.

Mr. Ford's major interest was, however, in the railway industry and he not only gave loyal service to the railways with which he was connected but took an unusually active interest also in the broader relationships of the railways as a whole to the economic life of the nation. He gave freely of his time and energy to the solution of these problems.

His interest in railway problems did not terminate with his retirement from active service; rather, this change in his status presented to him an opportunity to employ his experience to an increasing degree in helping solve some of the problems confronting the railway industry. He first conceived the plan of enlisting the interest of other retired officers of the company he had long served. Encouraged by the sympathetic support given to his plan by officers of the Rock Island, he undertook to or-

ganize the pensioned employees of that railway. The plan which he envisioned, however, was broader than the confines of a single railway. The program which he visualized was to be so comprehensive as to embrace all the railways throughout the United States and Canada, with their approximately 150,000 pensioned employees from all branches of service. He proposed to designate this organization as the National Railway Veterans Association.

Mr. Ford began work on this plan early in 1940 but failing health prevented its fulfillment.

ELMER T. HOWSON, *Chairman,*
D. J. BRUMLEY
E. M. HASTINGS
F. E. MORROW
C. A. MORSE
Committee on Memoir.

Memoir

Grier Ralston Smiley

Died June 10, 1941

With deep regret the American Railway Engineering Association records the death of one of its directors—G. R. Smiley, chief engineer, Louisville & Nashville Railroad. Mr. Smiley died on June 10, 1941, after an illness extending over the past year and a half.

Mr. Smiley, the son of Thomas M. and Ellen (Lantz) Smiley, was born at Moffatts Creek, Va., on February 6, 1880. He married Miss Nora J. Krome of Edwardsville, Ill., in 1911. He is survived by Mrs. Smiley and one daughter, Mrs. William Bowman Cutter; a brother, William V. Smiley, senior highway engineer, Public Roads Administration, State of Oklahoma; and a sister, Mrs. Richard Hogshead, Moffatts Creek, Va.

Mr. Smiley entered Washington and Lee University in the fall of 1898 and graduated in June 1902 with degrees of Bachelor of Arts and Bachelor of Science in Civil Engineering. He was an outstanding student, receiving certificates of distinguished proficiency in the departments of mathematics, chemistry, senior engineering and physics. In his senior year he was made instructor in civil engineering.

He entered railroad service as a rodman on the Hudson River division of the New York Central Railroad on September 1, 1902. On October 15, 1905, he accepted appointment as assistant resident engineer on the Florida East Coast Railway. Later he became division engineer and superintendent of construction in charge of a portion of that rail-

Grier Ralston Smiley

road's Key West extension. From 1912 to 1915 he was employed as resident engineer on construction of railroad lines in the eastern Kentucky coal fields for the Louisville & Nashville Railroad. Subsequently he served the Nashville, Chattanooga & St. Louis Railway as inspecting engineer on the construction of the Metropolis bridge over the Ohio River, connecting Paducah, Ky. and Metropolis, Ill. On January 15, 1917, he re-entered the service of the Louisville & Nashville as special engineer on surveys for reconstruction of bridges through the marshes of Louisiana, which position he held until September 6, 1917, when he was placed in charge of the miscellaneous department of the chief engineer's office. On September 1, 1920, he was appointed chief engineer of con-

struction, and on April 1, 1931, he was further advanced to assistant chief engineer. From August 1, 1933 until his death, Mr. Smiley was chief engineer of the Louisville & Nashville.

Mr. Smiley was a member of the American Railway Engineering Association from 1926, a director since 1939, and for a number of years served on the Committees on Rail, Masonry, Rivers and Harbors and on several others. He was a member of the American Society of Civil Engineers and served as president of the Kentucky section in 1936. He was president and director of the Engineers and Architects Club of Louisville for several years and a member of the Pendennis Club and the Big Springs Golf Club. He was a member of the Presbyterian Church, and for the past eight years and until his death, served on the advisory committee of business executives of Louisville for the Speed Scientific School, University of Louisville.

Mr. Smiley was distinguished and recognized as an authority by the engineering profession all over the country. He was awarded a Phi Beta Kappa key by Washington and Lee University for brilliant scholarship and outstanding engineering achievements after graduation. As an officer of the Louisville & Nashville and director of the American Railway Engineering Association he was a capable and respected executive.

Mr. Smiley was one of those rare individuals who need only to be met to be known immediately and subconsciously as a trustworthy friend. The cold record of his achievements shows his eminence as an engineer and gains respect, but cannot portray the frankness and human understanding so well defined by his character. He was loved by all who knew him, and no lesser word can convey the affectionate regard held for him by his friends.

The American Railway Engineering Association has sustained the loss of his wise and kindly counsel, and this memoir is in acknowledgment of his time and service so cheerfully and freely given.

J. B. Akers, *Chairman,*
L. L. Adams
C. H. Blackman
A. C. Irwin
G. P. Palmer
Committee on Memoir.

INDEX

A

Air conditioning equipment, servicing, 142
Air rights, suggestions for lease of, 113
American Society for Testing Materials
—AREA men on committees, 32
—activities of, 33
American Standards Association
—Representatives on Standards Council, 30
—AREA men on sectional committees, 31
Asphalt, use in ballast, 513

B

Blow offs, effect on track maintenance, 497
Bolts, tension tests, 550
Bond, F. L. C., address of, 641
Brine drippings
—preventing damage to track, 566
Buildings
—report, 123
—revision of specifications for, 123
—specifications for railway, 127
Built-up Roofing
—specifications for, 125

C

Canadian Engineering Standards Assoc., 35
Cars
—motor, 189
—push, 213
—trailer, 213
Cement, see Portland cement
Chemicals for water analysis, 74
Classification yards
—communication at, 143
Cody, Dr. H. J., address of, 652
Concrete, see also Masonry report
—specifications for railway buildings, 316
—specifications for railroad bridges, 337
Constitution, 10
Cooperative Relations with Universities
—report, 175
Corrosion, boilers, 82
Courts
—decisions on valuation, etc., 389
Crossings, highway—signs, 168, 169
Culverts
—specifications for corrugated metal, 481
—specifications for multiplate pipe, 483
—specifications for vitrified clay pipe, 489

D

Deceased members, 677
Douglas Fir
—specifications for preservative treatment of, 462
Drafting room practices, 383
Drills, power and bonding, 218

E

Eastman, Joseph B., address of, 666
Economics of Railway Labor, report, 229
Economies
—eliminating vegetation from ballast, 241
—operations of railways, 230
—spot welding of rail ends, 240
—stabilization of roadbed, 233
—use of highway motor vehicles, 238
Election of Officers, 646
Electrical energy
—form of agreement for purchase of, 108
Electrical equipment
—servicing, 142
Electricity, report, 37
Embrittlement of boilers, 82
Employees, young college men, 177

F

Fatigue Strength of Structural Members, m1
Fences
—corrosion resisting wire, 509
—specifications for wood posts, 510
Fire Protection Section, 84
Foaming, compounds, 85
Ford, Robert H., a memoir, 176; 243; m21
Foundations
—bibliography, 318
—test borings, 355
Frozen Products
—warehouse requirements for handling, 136

G

Gates, automatic crossing, 173
Gault, Paul M., memoir, 168; 176

H

Hovey, Otis C., a memoir, 364
Highways, report on, 167

I

Impact, report, 360
Interstate Commerce Commission
—changes in accounting classifications, 393
—valuation reports, 392
Iron and Steel Structures, report, 363
Irwin, A. C., grouting Chicago subway, 336

J

Joint bars
—failures, 602
—service tests of various types, 592

L

Lands subject to servitude, 47
Lehn, Henry, a memoir, 380
Locomotive
—modern types, 71
—water supply lines, 99

M

Maintenance of way accounts, 387
Maintenance of Way Work Equipment
—report, 187
Manganese castings
—welding of in special trackwork, 549
Marine organisms, destruction by, 435
Masonry, report, 257
Materials, priorities for purchase, 658
Memoirs
—Ford, Robert H., 176; 243; m21
—Gault, Paul M., 168; 176
—Hovey, Otis, 364
—Lehn, Henry, 380
—Smiley, Grier Ralston, m24
—Weidemann, Einar, 364
Moore, H. F., Eighth Progress Report, 607

N

Navigation, flooded lands, 47

P

Passenger terminals, modernization of, 149
Pipe
—cast iron, specifications, 81
—cleaning underground, 93
Pipe Line Crossings
—specifications for non-inflammable substances under pressure, 481
Portland Cement
—specifications for, 259
—chemical analysis, 262; 280
—sampling and physical testing, 285
—test for autoclave expansion, 314
—test for compressive strength of mortars, 300
—test for fineness by turbidimeter, 305
Posts, specifications for wood, 510
Power units—see Locomotives, 71
Priorities for railroad materials, 658

R

Rail
—battering, 591, 607
—continuous welding, 592
—controlled-cooled and Brunorized, 588, 625
—corrugated, 603
—drop and bend tests, 626, 635
—failure statistics, 576
—fissure failures, 607
—fractures under engine burns, 605
—metallurgical tests, 617
—reconditioning ends, 591
—record forms, 576
—report, 573
Records and Accounts
—report, 379
—bibliography, 381
Reflex units
—use of for switch lamps and targets, 548
Retaining structures, 499
Roadway and Ballast, report, 469
Roadway machines
—color of, 212
—lubrication of, 193
—new developments in, 206

S

Sanitation, railway, 83
Secretary, report of, 671
Sewers, cleaning, 93
Signal section activities, 43
Signaling developments, 41
Signals
—requisites for, 172
Signals and Interlocking, report, 41
Signs
—highway crossing, 168, 169
Smiley, Grier Ralston, a memoir, m24
Smith, C. E., remarks of, 664
Specifications, emergency provisions, 644, 770

Spikes
—specifications for high-carbon steel, 570
Soils, structural foundation, 471
Standardization
—recommended specifications, 26
—report, 25
—see American Standards Association
Steel Bridges
—specifications for rigid-frame design, 374
Switch lamps, reflex units, 548
Stevenson, Andrew, address of, 658

T

Talbot, A. N., illness of, 645
Tanks, welding specifications, 88
Termites, destruction by, 461
Test borings, specifications for, 355
Tie plates
—design of for RE rail, 547
—photoelastic study of stresses, 539
Ties
—dimensions, 401
—renewal statistics, 400
—report, 399
—service test records, 413
—splitting in, 401
Tools
—specifications for handles, 519
—wear limits for reclaimed, 522
Track
—circuit-coded, 42
—equated values, 235
—report, 515
Trackwork
—plans, 523
—specifications for special, 525
—welding manganese castings in special, 549
Train resistance study, 51
Tratman, E. E. R., testimonial, 714
Treasurer, report of, 680
Treating processes
—specifications for, 408
Tunnels
—maintenance, 507
—pressure grouting, 336
—specifications for brick lining, 331
—specifications for shotcrete lining, 330
Turntables, specifications for, 368

U

Uniform General Contract Forms
—report, 107

W

Warehouses, handling frozen products, 136
Water analysis, 74
Water columns, sizes of, 99
Water Service, Fire Protection and Sanitation, report, 73
Waterproofing of Railway Structures
—report, 357
—tests of asphalts and pitches, 358
Waterways
—high water mark, 47
—prevention of erosion by check dams, 474
Waterways and Harbors, report, 47
Weidemann, Einar, a memoir, 364
Wilson, W. M., monograph, m1
Wire or Cable Line Crossings
—form of agreement for, 115
Wood Bridges and Trestles
—report, 243
—specifications for design of, 244
Wood Preservation
—fundamentals, 407
—plant practice, 413
—report, 405
—use of chemicals, 449

Y

Yards and Terminals
—bibliography, 158
—report, 141
Yard communication, 42